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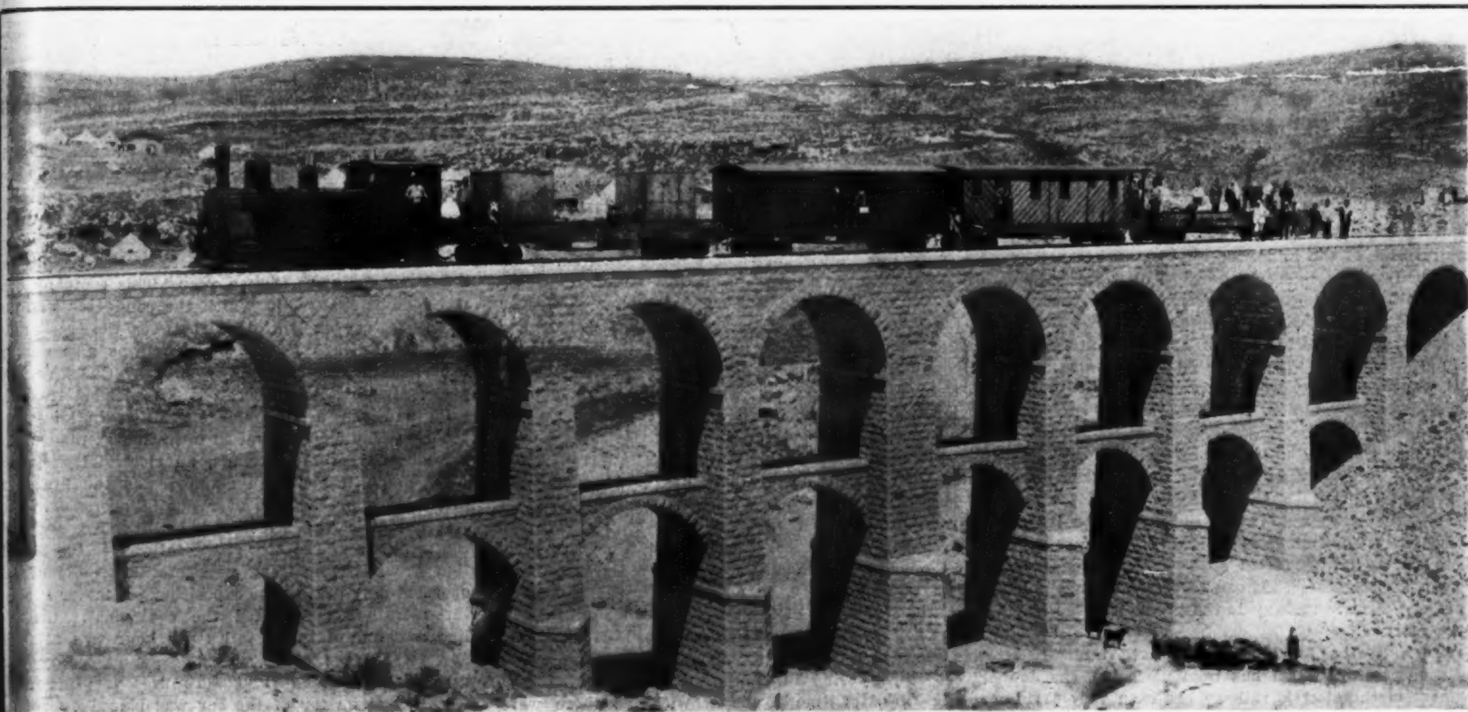


DOUBLE DECK MASONRY VIADUCT COMPRISING TEN ARCHES OF 20 FEET SPAN EACH. THE UPPER DECK CARRIES THE RAILROAD AND THE LOWER CONSTITUTES A HIGHWAY FOR PEDESTRIAN AND VEHICULAR TRAFFIC.

STEEL BRIDGE IN COURSE OF CONSTRUCTION, COMPRISING A CENTRAL SPAN OF 160 FEET WITH SMALLER SPANS OF 94 FEET EACH.

Photographs by J. Halladjan, Haifa.

THE HEDJAZ RAILROAD.—[SEE PAGE 248.]

DEVELOPMENT OF THE ELECTRIC RAILWAY.*

A RECORD OF MARVELOUS GROWTH.

BY JAMES N. HATCH.

It is not possible to define exactly when electric traction cars were first invented or to laud one inventor as the originator of the electric car. In fact, the modern electric railway has been evolved from a laboratory toy, and is as we see it to-day the product of the minds of many men. Each successive inventor has added a little here or a little there, until the result is the successful enterprise which is now coming into so much prominence.

The idea of operating cars by electricity was put into practice, experimentally, more than seventy years ago, but at that time neither dynamos nor motors had been invented and the use of the primary electric battery as the motive power for vehicles was not at all an encouraging problem. Another circumstance that effectually retarded the progress of the electric railway was the success attained about this time by the steam roads, which seemed to solve effectually most of the important problems of transportation. A few experiments were carried on from time to time both in America and in Europe, with battery-driven cars, but very little encouragement was found in these attempts. And it was not until after the year 1867, the year in which the dynamo was perfected, that any real progress was made toward a large electric car suitable for the practical carrying of passengers.

Following promptly upon the commercial exploitation of the early magneto-electric and dynamo-electric generators, came a sharp renewal of the effort to perfect the electric railway. But even then it required twenty years of experimental work before any system was so far perfected as to show evidence of real commercial success. It can therefore be said that the modern electric railway is the product of the last twenty years.

However, in the few years that have intervened since a successful system has been perfected, the development of the electric railway has been very rapid and the outlook for the future is stupendous. The electric roads now in operation in the United States would, if collected together, furnish enough trackage to build a ten-track line from New York to San Francisco, and the cars in use would, if placed end to end, make a continuous wall reaching from Chicago to Pittsburg. There are more miles of electric road in the United States than there is in all the rest of the world put together, and the electric roads in the United States have more mileage than the combined electric and steam roads of any one European country. The present growth represents an equivalent of a new line from Chicago to San Francisco every year.

This growth and advancement from year to year has been little less than marvelous. The average rate of construction for the past six years has been 2,500 miles per year, which represents a growth per annum of more than half of the annual growth of the steam roads for the same period. And this represents practically all new work, for the changing over period had nearly ceased before the year 1900.

With these facts in mind it is not difficult to believe that the time is at hand when the electric railway must be seriously reckoned with in the financial economies of this country. At the present rate of increase there will soon be a perfect network of interurban lines throughout the entire densely populated portion of the United States. Probably during the present summer, electric cars will run through from Chicago to Louisville and Cincinnati, and it will be but a short time until it will be possible to go from Chicago to Detroit and Cleveland on electric cars.

According to the United States census report of 1890, there were in 1886 two electric railways in successful operation, with a combined mileage of eight miles; in 1887 there were four roads with a combined mileage of twenty-nine miles; while in 1888 the business had increased until there were then in operation twenty-nine roads with a combined mileage of nearly three hundred miles.

For a number of years prior to 1886 there had been numerous attempts made to put in operation a successful electric car, and it was confidently believed by the various inventors that electricity was adapted to the propulsion of street railways; yet none of these attempts were so far successful as to supplant the well-established methods of operation with horses or steam dummies. While every attempt which had been made was of inestimable value in forming a stepping stone to better things, some weak spot always developed, that rendered the enterprise a financial failure. But these obstacles, while very disheartening at the time, did not seem to discourage the designers of these early days, but only served to awaken them to the necessity of renewed efforts to perfect the system which they believed destined to be rewarded with success.

As early as 1880 the electric motor had been so far perfected and simplified that the outlook for a practical electric car was encouraging, and a number of designers were in the field working on schemes to make electric traction a success. In 1881 and 1882, Leo Daft began experiments with a commercial size electric car, firm in the belief that it was possible to replace the horse as a motive power for street railway by electric traction. Mr. Daft formed the Daft Electric Company, and made a large number of public tests for the purpose of demonstrating the practicability of the Daft systems of electric traction. This company built an electric locomotive which they called the "Ampere," for use on the Mount McGregor steam railroad at Saratoga, and during the summer of 1883 equipped about 1.25 miles of that road with 35-pound third rail, mounted on resinized wood blocks in the center of the track, with soft rubber insulation under the foot of the rail and bolt heads. Experiments were continued for two or three weeks with more or less success. One feat of the "Ampere" is described as hauling an ordinary day coach containing 69 passengers over a curve of about 100 feet radius up a grade of 93 feet per mile.

Following the Saratoga experiment, the Daft Electric Company in 1884 built several show lines at Coney Island and elsewhere, to advertise to the people at large the feasibility of the system. As an outcome of the Coney Island demonstration, the Daft Company was awarded a contract for about two miles of actual street railway line in Baltimore. This was a very trying piece of line to begin with, as there were grades of 350 feet to the mile, and curves of from 40 feet to 70 feet radius, with a gage of 5 feet 4.5 inches. The line was owned by the Baltimore Union Passenger Railway Company, and the contract with the Daft Company was entered into in 1885 and work upon the equipment was started forthwith. Many troubles developed in the installation and subsequent operation of the line, but it was operated with enough success to attract the attention of capitalists and to awaken ambitious engineers to the belief that there was really a power almost within their reach which was destined to revolutionize the street railway business.

With this line an electric locomotive hauled the regular street cars. These locomotives or dummies were equipped with motors placed on the floor of the car and the axles of the car were driven by large gears. The track was equipped with a third rail to supply current, placed midway between the track rails, which were used for the return circuit. An overhead trolley was used where long crossings were encountered, and it was in this way that the first trolley system was put into operation.

Daft says of his Baltimore road which was put in operation in 1885, that "therewith the first commercial electric railway in America had hung up its shingle."

This suburban road continued in successful operation until 1889 or until it became part of a network of electric railways which were equipped with more modern apparatus. Daft introduced the double trolley system of electric traction with a trolley wire return. This system is still in operation in Cincinnati.

In 1888 Daft placed on trial a large electric locomotive, on the Ninth Avenue Elevated Railway in New York. This locomotive was called the "Ben Franklin" and was placed in service with the hope of showing the advantage of this motor over the steam locomotive then in use. These trials were conducted under a variety of conditions, in an endeavor to convince the most skeptical of the advantages of electric motive power for elevated roads. This motor was able to draw six of the ordinary elevated cars at a speed of forty miles per hour. These experiments were thoroughly successful, but the necessity of changing from steam to electricity did not seem to be apparent at that time, and in fact was not fully realized for a long time afterward.

During the time that Daft was carrying on his early experiments in the East a number of inventors in the West were making experimental efforts to demonstrate other systems of electric traction. One of these early railways which gained considerable prominence, and which was among the first electric railways successfully operated, was that at the Chicago Exposition in 1893. An electric locomotive known as the "Judge" operated for some time during the exposition on an intramural railway, and hauled 26,000 passengers. The "Judge" was made in accordance with the design of Edison and Field, who had combined their efforts in electric railway design. The "Judge" weighed about three tons and drew a trail car for passengers.

In the fall of the same year Messrs. Bentley and Knight, who had witnessed the performance of the "Judge" at Chicago, formed the Bentley-Knight Railway Co., and constructed a short experimental electric railway in the yards of the Brush Electric Company at Cleveland. The results of the experimental line were so encouraging that during the next year this company constructed a line over a mile long in Cleveland, and operated cars with more or less success and constancy for more than a year. This company used the conduit system, in which the conductor was carried in a wooden box placed between the track rails.

At the Chicago Exposition there was also another experimental electric railway built by Chas. Van Depoele. In this line the car was suspended from the rails and ran around the exposition building. In 1885 Mr. Van Depoele put in operation at the Toronto Exposition, Toronto, Canada, an electric trolley railway, which it has been claimed was the first commercial trolley car line ever put in operation. This was not strictly a street railway line, but ran from the terminus of the city street railway to the Exposition grounds, something over half a mile, and was operated only during the exposition. A motor car and three trailers constituted the equipment. On this line a speed of thirty miles per hour was attained and an average of 10,000 passengers per day were carried. The track rails were used for the return circuit, and on top of the car was placed one of the first illustrations of the under-running trolley now so universally employed.

Mr. Van Depoele's next venture was the construction of a regular street railway in South Bend, Ind. On this line were operated as many as five separate cars, something never before attempted or even supposed possible. This road derived its current from a generating plant driven by water power. There were four ordinary closed cars equipped with one 5-horse-power motor each and one large car equipped with a 10-horse-power motor. On the cars the motors were placed under the car body between the wheels and the axles were connected by means of sprocket wheels and link belts. This arrangement of putting the motor below the floor of the cars was found to be advantageous, as the earlier arrangement of placing the motor on the floor of the cars took up much valuable space which could be used for passengers. On this road an innovation was introduced in the use of the over-running trolley instead of the under-running style, as was used at Toronto. The cars on this line were not reversible, but always run the same end forward. The first use of the carbon brush motor is also attributed to Mr. Van Depoele and was put into operation on the line.

Prior to the introduction of the carbon brush in railway motors, the brushes used were similar to the then prevalent type of dynamo brushes made of thin strips of copper. These brushes were a never ending source of trouble in railway work, due not only to their inherent unreliability under the rough use on a railway motor, but due also to the trouble from dirt and moisture which was encountered along the unimproved streets. These early motors were of the open type and offered little protection from dust and weather.

Some of the early types of motors were fitted with two commutators and two sets of brushes, one on either end of the armature, and it was no uncommon thing for the motorman to stop two or three times per trip and put in new brushes.

The rheostat or resistance for regulating the speed was also a complicated and annoying piece of apparatus. It was at first placed beneath the car and manipulated by a coffee mill style of controller, which the motorman ground around two or three times to throw on the power. Afterward this rheostat was placed upon the platform, but was always a menace to life and limb.

These things seem amusing now as we examine them in a reminiscent way, but they were most exasperating at the time, for an exhibition of trouble

* Paper read before the Western Society of Engineers.

a street railway car partook of so much publicity from the very nature of things that every little trouble seemed to be magnified, and it was hard to convince the public that such troubles were only transitory, and that their discovery meant their elimination. It required just such enthusiastic experiments as the South Bend road to show up the weak spots and pave the way for better things.

Following the construction of the South Bend road, Mr. Van Depoele built a large number of lines, under his system, during the next few years, some of which continued in operation and some of which fell by the wayside. One in particular, which was constructed in Windsor, Canada, in 1886, was remarkable to the writer as constituting the first electric railway which he had ever seen. He visited Windsor and examined the railway with a great deal of interest. At the time of this visit the road was in a state of innocuous desuetude and apparently had been in that state for some time. The one car, the total equipment of the road, stood at the end of the line, where it had apparently stood motionless for many moons. The trolley was a miniature car which was drawn along the trolley wire by a flexible conductor.

The Van Depoele Company was absorbed by the Thomson-Houston Company in 1888 and Mr. Van Depoele became an engineer for that company. The following year the Thomson-Houston Company took over the Brush Company, which also brought the Bentley-Knight Company into the consolidation.

At about this same time Mr. John C. Henry, of Kansas City, was working on an electric railway system of his own invention, which attracted considerable attention. He put in operation several experimental lines, using the Van Depoele motor and the trolley collector with overhead wires. In the fall of 1885 he conducted a series of experiments with heavy electric equipment, on a branch of the Fort Scott Steam Railway, where freight cars were hauled by electric motors. He also attempted high speeds and operated over heavy grades under all sorts of varying conditions to demonstrate the practicability of equipment. These experiments were carried on during severe winter weather, to demonstrate the effect of deep snows. The following year he equipped the Kansas City Fifth Street Railway with his system. In 1887 Mr. Henry moved to San Diego, Cal., where he built a number of lines, one of which had grades of 9 per cent. The system of underground feeders was first introduced on one of these roads.

Coincident with Mr. Henry's work in Kansas City, some interesting work was being carried on in Denver by Prof. Sidney H. Short, of the University of Denver, upon an experimental electric railway 300 or 400 feet long upon the college campus. Prof. Short believed in the series system of distribution and used this system on his lines. The cars used on the campus line had a rigid four-wheel truck, and the motors were geared with one pinion and gear to the axle. The car body was eight feet long. The success of this line was so great that a party of capitalists induced Mr. Short to give up his professorship and develop a commercial electric street railway. The conduit system was adopted and five miles of track were laid on 15th Street, Denver, and operated with considerable success for some time. The difficulty of insulation in the conduit in wet and snowy weather and the imperfection of the early types of motors and generators led to electricity being finally abandoned for the cable, which, however, has since been changed back to electricity.

Mr. Short afterward went to Columbus, Ohio, and to Cleveland, where in 1889 he organized the Short Electric Railway Company. This was merged into the Walker Electric Company shortly afterward, and the Walker Company was finally taken over by the Westinghouse Electric and Manufacturing Company.

It is thus seen that the early eighties were active years in competitive demonstrations of electric railways, but all of these enterprises were more or less experimental, and all of the equipment used prior to 1887 was destined to be superseded by more economical and efficient apparatus.

With the year 1887 began the actual construction of actual roads, for with that year the vast numbers of previous experiments began to bear fruit in the way of practical results.

On December 31 of that year there were twelve successful electric railways being operated in the United States and Canada with an aggregate mileage of less than fifty miles of track. The electrical equipment of these twelve roads consisted of fifty or sixty motor cars. Of these roads, six were on the Van Depoele system, three on the Daft system, and one each on the Fisher, Short, and Henry systems.

This was the situation when Mr. Frank Sprague entered the electric street railway field. There was no standard of construction either in size of cars, style of equipment, gage of track, kind of rail or method of power transmission. Mr. Sprague had been working for a number of years upon the perfection of his motor and had established himself in the field of stationary electric motors before attempting to use his motors for railway service, and his first active work in this line was begun in 1887. Prior to this he had done considerable experimental work with his motor in New York upon a private track and upon the 34th Street branch of the elevated railway.

In the spring of 1887 the Sprague Electric Railway and Motor Company received contracts for roads in St. Joseph, Mo., and Richmond, Va. The Richmond road is generally referred to as the first successful electric railway ever constructed, and while this does not imply that the roads of Van Depoele, Daft, and others would not have been successful when the obstacles were overcome, and in fact were improved afterward until they were successful, it still remains a fact that the Richmond road was the first to work out of the preliminary difficulties and attract attention as a thoroughly successful commercial enterprise, worthy of copying.

After twenty years of development we would now look upon the construction and equipment of the Richmond road as a boy's size affair, but at that time it was the biggest thing of the kind ever attempted. The road was a new one, as distinguished from the changing over of horse-car lines, and included a complete generating station, erection of overhead lines, and equipment of forty cars with two 7½-horse-power motors each, on plans largely new and untried. The contract required that it must be possible to operate thirty of these cars at one time. The conditions in Richmond made the requirements for grades and alignment very severe, and the road as built had 29 curves, some of them of less than 30 feet radius, and grades reaching 10 per cent. The contract required the completion of the entire track ready for operation in 90 days. The track was laid with 27-pound rails. The overhead construction consisted of a small trolley wire reinforced with a continuous main conductor placed over the center of the track and supplied with current by feeder circuits from the main power station. The track constituted the return circuit, the rails being bonded together and connected with a continuous conductor, which was also connected with the ground plates and with the water and gas mains of the city. The power house was equipped with small belted units and generated constant potential current at about 450 volts. The cars were 16 feet in length, and as said, were equipped with two 7½-horse-power motors. These motors although built according to the best known design at that time, constructed in one of the best equipped electric manufacturing shops of the country, were so poorly adapted to the service that was required of them that every one of them required the rewinding of its field coils and armature and the changing of its commutators. The principal characteristics of Sprague's motor-equipment as used on the Richmond road, which contributed largely to its success and was an improvement over earlier systems, were an independent truck with motors exteriorly centered upon the driven axle so as to maintain parallelism between the driving shaft and the driven axles, flexible supports for part of the weights of the motors on the trucks to allow perfect freedom in following the motion of the axles, suspension being below the car springs. The method of flexible suspension avoided all shock and jar. He also used fixed brushes, allowing forward and backward running. This equipment marked the abolishing of ropes, belts, sprocket wheels and chains for the reduction between armature and axle.

In spite of many difficulties and a host of obstacles which had to be overcome, the Richmond road was a success and continued in operation until it was later absorbed by a more modern system. This road attracted wide attention in street railway and financial circles.

The Sprague Electric Railway and Motor Company depended largely on the Edison General Electric Company for the manufacture of motors, and in this way the Edison Company became interested in the electric railway field. The Edison Company advanced money to Sprague to carry on his business, a consequence of which was that the Sprague Electric Railway and Motor Company was soon absorbed by the Edison Company, all of which were later merged into the General Electric Company.

After the year 1888, the electric railway business of the United States was established on a firm basis. The large electric manufacturing companies which had already developed an extensive business in the electric lighting field, became interested in the manufacture of electric railway equipment. The Thomson-Houston Company was one of the pioneers in railway motor construction. The first step in this direction was the purchase by it of the patents of Bentley and Knight, and those of Van Depoele. Shortly afterward the Thomson-Houston Company took over the Brush Company and began on a large scale the construction of railway motors. The services of Mr. Van Depoele were also secured in the designing department of this company. The first motors turned out by the Thomson-Houston Company were what were known as the F-30 motor. This was a 15-horse-power motor, and two were used to the car. Four thousand six hundred of these were sold by this company during the years 1888-91. These are said to be the first motors on which the carbon brush was used. Without the carbon brush the railway motor could never have attained the success it has.

In 1890 the Edison General Company took over the Sprague Company and actively entered into the manufacture of railway equipment. Shortly after this, several of the men who had been active in the Sprague Company, and who owing to the consolidation of the Sprague and Edison companies, were left on the outside, induced the Westinghouse Company to take up the manufacture of railway motors.

Thus with the year 1891 there were three large companies actively competing for this class of business. In 1892 the Edison General and the Thomson-Houston companies were merged into the General Electric Company. Since that time this company and the Westinghouse Company have been the two principal factors in electric railway manufacture. The Westinghouse Company in 1898 took over the Walker Company, of Cleveland, who had eight or nine years previously secured the services of Prof. Short as chief engineer.

(To be concluded.)

RURAL DEPOPULATION IN GERMANY.

The rapid transformation of Germany from a country where the rural villages were for centuries the principal factor, into one in which the city population is very largely in the majority, is causing both German economists and statesmen serious thought. At the present time, attention is frequently called to the necessity of administrative reforms, due to the fact that in many parts of the German Empire the rural population is becoming very small, and that practically everywhere the cities contain not only the larger part of the population, but control the bulk of the wealth as well. At the founding of the German Empire in 1871, the rural communities (those with less than 2,000 population) contained 64 per cent of the population of the empire. In 1905 the rural population was only 48½ per cent of the whole. In some districts, such as the Rhineland, Westphalia, Oldenburg, and the kingdom of Saxony, the rural character of the population has nearly disappeared, the percentage of the rural population in these places being only 23, 23.5, 24.9, and 28.8 respectively of the whole population. In the kingdom of Saxony, the city population has, according to the American consul at Annaberg, increased from 1,265,057 in 1871 to 3,211,408 in 1905, while the rural population during the same period increased only from 1,291,187 to 1,297,193. The strictly farm villages of from 100 to 1,000 population show actual decrease of from 7 to 9 per cent for the same period. Nearly one-third of the population of the kingdom is found in the five large cities of Dresden, Leipzig, Chemnitz, Plauen, and Zwickau, and more than half the population in the cities of 10,000 inhabitants or more. In many of the suburbs of the larger cities, once purely village communities, but now swallowed up by the cities, the increase in the population for the five years from 1900 to 1905 was almost phenomenal, averaging from 75 to 80 per cent, and in some instances running as high as 200 per cent. Saxony is the most densely populated of the German states. In 1871 it had a population of 441 per square mile, and this at the last census enumeration (1905) had increased to 779 per square mile. The population of the three large cities, Leipzig, Dresden, and Chemnitz, was respectively 22,875, 19,842, and 15,930 per square mile. Next to Saxony, the most densely populated parts of the German Empire are the Rhine province of Prussia, with 616 inhabitants per square mile, and the principality of Reuss the Elder, with 577 per square mile. The average for the whole empire is 290 per square mile.—Journal of the Royal Society of Arts.

In an article published some time ago in the Electrical World, the author says it is generally assumed that the volume of the insulation of a square-core winding is $L\ (c^2 - a^2)$ where L is the length of the wire, c the side of the covering, and a the side of the wire. This formula, however, gives very erroneous results in practice, as the corners of the outside covering are always rounded. If t be the thickness of the insulation, a better formula is $4Lt\ (a + 0.785t)$. This is obtained by assuming that the section of the copper is a perfect square. As these conductors usually have their sharp edges rounded off a more accurate formula is $Lt\,[2(a+b) + \pi t - 1.717r]$, where a and b are the side of the rectangular section, and r the radius of curvature of the corners. The economy of insulation effected by using round instead of square conductors is generally exaggerated. For equal cross-sectional areas and for an infinitely thin covering the saving effected would be 12.8 per cent. In practice, however, the saving effected is inappreciable.

PNEUMATIC CAISSONS.—II.*

HOW THEY ARE EMPLOYED IN ENGINEERING CONSTRUCTION.

BY T. KENNARD THOMSON.†

Concluded from Supplement No. 1710, page 236.

River caissons are usually built either on the shore and skidded or launched into the river, or else are built on a pontoon, made of two or more parts bolted together. A pontoon is usually made by spacing 12 x 12 inch timbers about 3 or 4 feet apart and spiking 3-inch plank on the bottom and then building side walls of 3-inch plank about 6 feet high, the bottom and sides being well calked with oakum, giving a dry platform to build and calk the caisson on. We usually build the sides of the caisson about 14 feet high above the cutting edge, when we expect the caisson to draw 8 or 9 feet of water after the pontoon has been removed. But before this is done it is necessary to attach the bottom sections of the excavating and main shafts as well as all air and blow pipes, and gas pipes for electric wires and whistles.

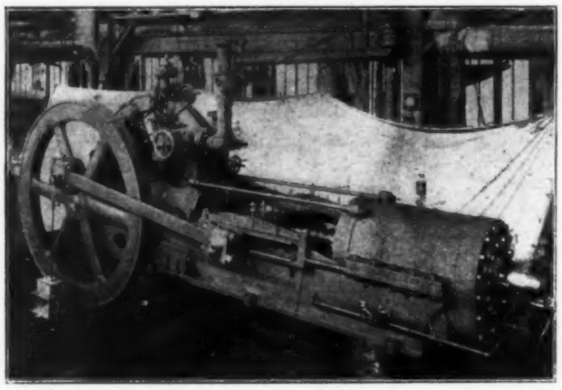
The method usually adopted for removing the pontoon from under the caisson is to weight the center of the pontoon with gravel or stones and remove the bolts which connect the two halves together, and then flood the pontoon by opening a valve or two, which allows the caisson to float and removes the weight of the caisson from the pontoon. The pontoon then acts up against the caisson according to the displacement of the pontoon when submerged, itself, instead of according to the much greater displacement of the caisson. If sufficient weight has been placed on the pontoon, each half will often shoot from under the caisson as it sinks. At other times it is necessary to attach tugs to pull the pontoon sections away, or to rig up a few struts with block and tackle connected to a hoisting so arranged as to force the parts of the pontoon under the caisson down and out. While this is generally the operation of a few minutes, it is often bungled, and it once took several weeks, first because a green man tried to pull the pontoon away without sinking—thus pulling against the entire weight of the caisson, and second, because he allowed enough water to get in to freeze the caisson to the pontoon, and then sank them frozen together—a very expensive lesson.

The pontoon can, of course, be used over and over again; in fact, as often as there are caissons on the job, unless time is an object, when it will often pay to build two pontoons. Caissons from 60 to 100 feet long will often take three or four weeks to build, if built by an expert, before they are ready to launch, which is a serious amount of time if 10 or 12 caissons are to be sunk in one season.

Caisson work in winter always costs more than if done in the summer, owing to the extra consumption of coal, trouble of packing air pipes to prevent freezing, to say nothing of the danger of ice and floods. Sometimes in silty rivers where if a channel was dredged to float the caisson it would fill up at once with silt, it is necessary to build the caisson on a platform supported by piles at the site where it is to be sunk and to attach a dozen or so rods about 2 or 3 inches diameter to the cutting edge. The rods are threaded for most of their length and pass through plates held on frames around the caisson in such a way that when the caisson is completed it can be hung from these rods. By turning the nuts on the rods simultaneously the caisson can be lowered until it floats or until the resistance under the cutting edge is sufficient to support the caisson while the cofferdam is being placed on top. The rods are so arranged that as soon as the caisson is landed they can be disconnected and used over again for the next caisson. A caisson can usually be lowered in less than a day by this means, so the expense is not very serious.

It is very important to see that the site for the caisson is level before putting the caisson in position, and if it is not it should be dredged as nearly level as possible, otherwise the caisson will be thrown out of plumb and probably warped at the outset, and then will cause trouble all the way down.

The expedient of dumping material in the low shots to level up is a very poor one, as the dumped material will not give nearly as much resistance to the



INGERSOLL-SERGEANT CLASS A COMPRESSOR.

INGERSOLL-RAND DRILL USED AS A PILE DRIVER.

LAUNCHING A CAISSON.

TOWING A CAISSON TO POSITION.

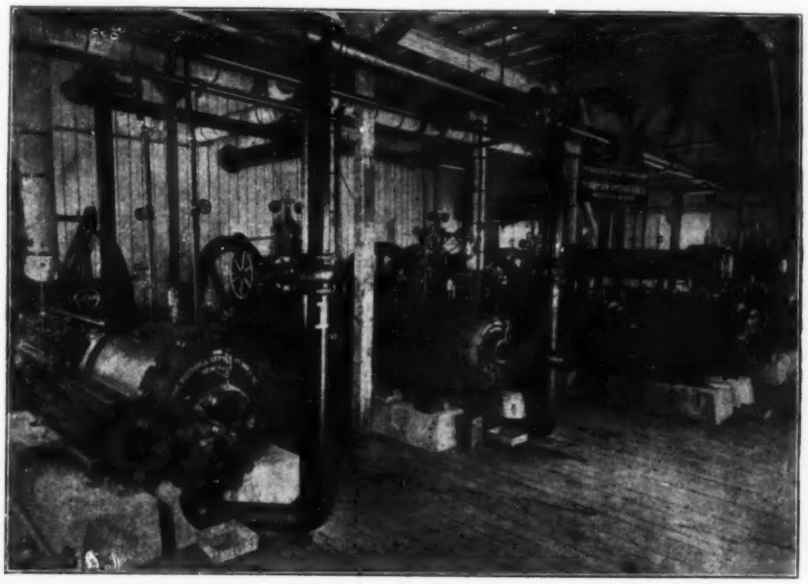
PNEUMATIC CAISSONS.

* Reprinted by permission from Railroad Age Gazette.

† Mr. Thomson designed the caissons for the railroad bridges across the Monongahela River at Pittsburg, the Ohio River at Mingo Junction, the Susquehanna at Havre de Grace, the Missouri at Pierre, S. Dak., and others, and for the stone arch highway bridge over the Connecticut River at Hartford, Conn.

cutting edge as the original surface, and distortion will probably occur. It is an exceedingly difficult matter to handle a warped caisson, and once a caisson is warped it is almost impossible to level it up again. As a caisson which does not start right in this respect seldom finishes right, half the battle is in the start.

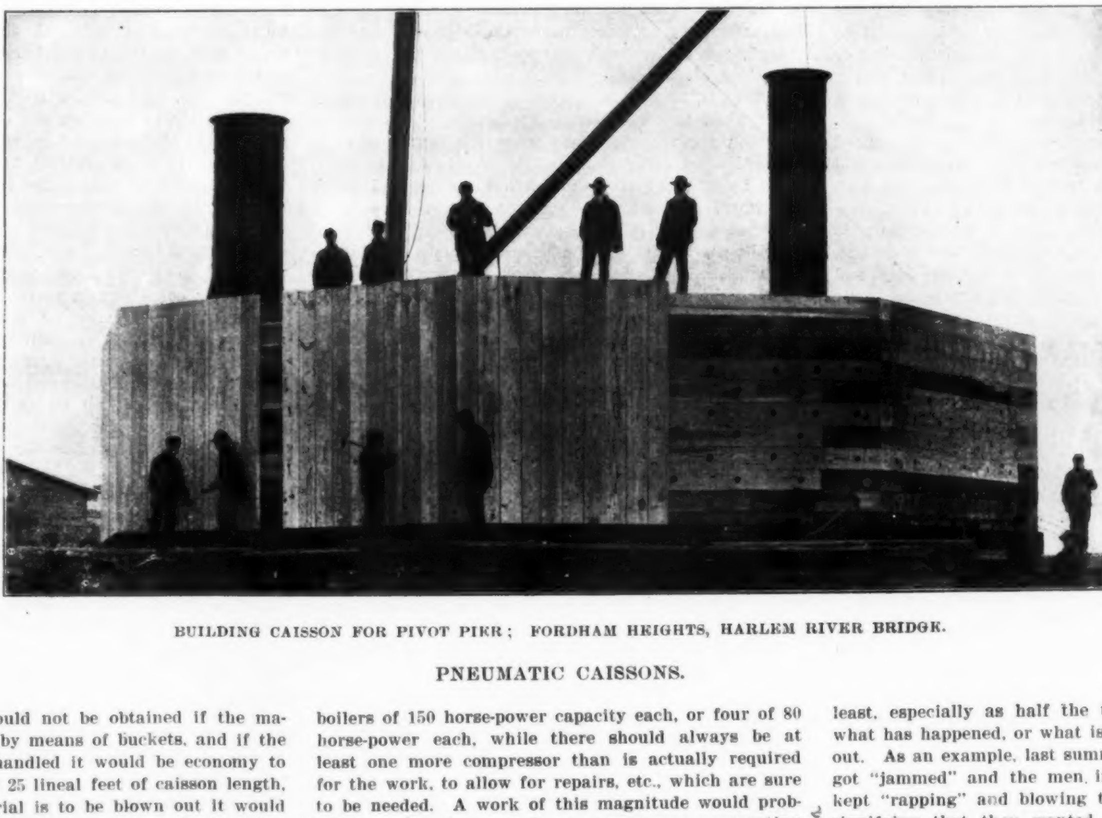
Caissons sunk on land are held in place by shoring against any available structure until the cutting edge has penetrated sufficiently far to prevent loss of control. In a recent New York city job the concrete caisson standing 20 feet in the air was insufficiently shored up, with the result that it fell over—a total wreck—costing the contractors several thousand dollars.



INGERSOLL-SERGEANT CLASS A AND CLASS A C COMPRESSORS.

In river caissons clusters of piles are usually driven, when possible, near the four corners about 5 feet or so away from the caisson, and a guide frame is placed between these piles and the caisson. These piles also serve to attach the sand-hog boathouse, the derrick boats, as well as scows of sand, stone, and cement—making quite a cluster of necessary boats. The derrick boat often carries a 2 cubic yard concrete mixer with hoppers or bins above to hold the sand, stone and cement, and should have at least two booms, one for unloading the material from the scows, using a clam-shell bucket for the sand and stone; and one to handle the concrete bucket, and when necessary the cofferdam material.

In many cases where the material is "blown out" it can be excavated faster than the cofferdam can be built and calked, so it would sometimes pay to have a separate derrick for building the cofferdam. This rapidity of sinking could not be obtained if the material were excavated by means of buckets, and if the material is to be so handled it would be economy to have a shaft for every 25 lineal feet of caisson length, and even if the material is to be blown out it would pay to have frequent shafts for economy in handling the concrete. But contractors will not as a rule put in so many shafts, for even if the caisson is 130 feet long, they will probably not use more than two excavating shafts and one main shaft—the latter also being used at the end for concreting the working chamber.



BUILDING CAISSON FOR PIVOT PIER; FORDHAM HEIGHTS, HARLEM RIVER BRIDGE.

PNEUMATIC CAISSONS.

The pipes for supplying the compressed air are generally 4 inches diameter, and there should be at least two from the deck to the top to facilitate changing the connection, etc., as the cofferdam is added to. One 4-inch line is sufficient from the caisson to the compression plant, with smaller pipes for high pressure to operate the locks. In winter it is necessary to place these in a box filled with manure, for I do not know of anything that will freeze quicker than a compressed air pipe.

The compressor plant with electric lighting and pumping plants is sometimes compactly arranged on a big float, though it often pays to place the entire plant on shore alongside of a railroad track on account of coal, etc.

In many cases we find an existing bridge parallel to the bridge under construction where the pipes find plenty of points of support, and in other places a light trestle is built or the piles can be laid directly on the bottom of the river, which, however, is not so desirable.

It is impossible to lay down any cast-iron rule for the size of the plant required, for it will depend not only on the number of caissons to be sunk at the same time, but also on the time of year or climatic conditions. It always pays, however, to have plenty of boiler capacity, say, for a fair-sized bridge, two boilers of 150 horse-power capacity each, or four of 80 horse-power each, while there should always be at least one more compressor than is actually required for the work, to allow for repairs, etc., which are sure to be needed. A work of this magnitude would probably require three or four compressors aggregating from 2,500 to 3,000 cubic feet of free air per minute.

Nothing is so expensive on contract work as delay.

The Ingersoll-Rand straight-line compressors and the compressors of the Norwalk Company are among the best in the United States.

Reference has been made to the effect of the weather and locality on the cost of caisson work as regards coal, etc., and I may give two examples, in both of which the work took about one year, winter and summer. The first case was in the East, where there were some 20 medium-sized river caissons using 5,000 tons of coal at $3, making the total cost of coal about $15,000. The second was in the West, and though there were only about one-half as many caissons and the total cubic yards of caisson work was only about one-half in the western bridge as in the eastern one, the amount of coal, owing to the severe weather, was the same, while the price was $8 a ton, making the total cost of coal $40,000, which made the coal in the second bridge cost over five times as much per cubic yard of caisson work for the western bridge as it did for the eastern one, although both were handled by the same contractor, with the same plant and same staff. This is one of the reasons why it is so hard to figure the cost of pneumatic work in advance.

One of the best money-saving devices for a contractor who has a number of caissons to build is a saw arbor run by compressed air or electricity. The saving in time in cutting the 12 by 12 timber to the right length, as well as the smaller sizes, pays for the machine in a very short time.

A really good pipe-cutting machine with dies, etc., is also indispensable, as also are pneumatically run augers for boring holes for bolts and drift bolts, and a pneumatic hammer for driving the same. An ample number of the best stiff leg and guy derricks and necessary side tracks, wharves, cement, and other buildings will well pay for the outlay, large though it is.

Pneumatic caisson work is sometimes contracted for at below $20 per cubic yard, but there are not many places where a contractor can take the work at this figure and complete his undertaking except at a loss, while in some places the cost runs up to $40 or $50 per cubic yard. As a general rule the cost of caisson work per cubic yard for the foundation of New York skyscrapers is about double what the pneumatic work for a fair-sized bridge outside of the city would cost.

The only proper way to light the air chamber now is by electricity, so where current cannot be purchased readily it is necessary to install a good electric light plant.

Telephone connection from the working chamber is also useful, and in some emergency cases would be invaluable in saving life and property. One of the most unpleasant accidents is to have the bucket stuck in the shaft when the caisson has only one shaft and lock for men and material. This has frequently happened, keeping the men in the air from 10 to 12 hours overtime, sometimes with very dangerous results, for the men have used up their energy and have no food to replenish with, and are, besides, nervous about the outcome—a very disagreeable combination, to say the least, especially as half the time they do not know what has happened, or what is being done to get them out. As an example, last summer the door of the lock got "jammed" and the men in the working chamber kept "rapping" and blowing the whistle (five times) signifying that they wanted to come out. At first the men outside answered back with two raps, which means "hold" or "you will have to wait," but after a

while the outside men who were working over the lock got tired of answering, so the sand hogs stopped signaling; and after quite a long silence the outside men signaled repeatedly without getting any answer whatever, and becoming alarmed for fear that the sand hogs were paralyzed, they took the bull by the horns and took the whole lock off, allowing the surrounding material to enter the working chamber. The minute the lock was off the sand hogs, who had purposely refused to answer the signals, clambered up the ladder and went home. This paper could be filled with equally exciting experiences.

The men who work in the air chamber, better known as sand hogs, are a hardy, reckless set. Until a few years ago they only received $2.50 per day of 8 hours in New York city for pressure up to about 20 pounds per square inch above atmospheric, the price rapidly increasing above that as the pressure increased and the hours of labor decreased, until at about 45 pounds per square inch they only labored 1½ hours per day, and even that was divided into two shifts of three-quarters of an hour each, with a rest of four hours in between. Very few fatalities occur in the lower pressure and long hours, but many occur when the pressure is over 40 pounds per square inch.

Now, however, the unions have raised the lowest figure to $3.50 a day, the actual working time being 7½ hours with a half hour for lunch. This requires three shifts a day: from midnight to 8 A. M., from 8 A. M. to 4 P. M., and then to midnight; for once the compressed air is in the working chamber work should not stop until the excavation is completed and the air chamber filled with concrete. For not only do stoppages increase the friction on the sides, but there is always a danger of accidents if there is no one in the air chamber but a watchman, since both the watchman and the gage tender outside are liable to go to sleep, and they have often done so, allowing the pressure to either go up too high and blow out or fall too low and draw the material in, sometimes allowing the caisson to sink until the working chamber is completely filled with material, which is removed with difficulty.

While the hours laid down by the unions are supposed to be all that the men can ordinarily stand, nevertheless, by taking care of themselves they have occasionally worked more than twice as long, but not continuously, day after day.

While watching a certain piece of work I went in and out of the air chamber for 86 hours without going to bed, and that, too, in pressures up to 35 pounds per square inch above atmospheric. But I have had the bends twice, and do not propose to take the risk again, even though I only stay down a few minutes at a time.

The best sand hogs are Irish and Swedes, two classes that do not like each other very much, calling one another "square" and "round" heads. I have also had some very good colored men. Italians as a rule do not care for the work. Sand hogs cannot be classed under the head of skilled labor, which is the reason why the men are not better paid, for all that is needed is a good constitution and plenty of pluck. With these two qualities the ordinary sand hog can learn all he needs to know in a day, and he will do a big day's work when in the air chamber, using or burning up his energy, which likewise gives him a big appetite, so that we seldom see a lean sand hog, nor do we often see an old one.

The foremen and superintendents, however, need years of experience and the ability to act quickly and fearlessly in emergencies, lack of which qualities have been fraught with disastrous results to life and property. For instance, in excavating it is customary to dig down in the center about a foot or two at a time, leaving a small bench around the cutting edge and then removing this just before they are ready to let the caisson "drop," which is often accomplished by lowering the air pressure for a few moments. Now a good foreman will see that he gets an accurate report from the engineers at least twice a day, preferably just before 8 A. M. and 4 P. M., giving the exact position of each of the four corners as regards elevation and location, from which he will determine how much to throw the caisson by undermining one side more than the other, etc., and thus prevent the caisson getting away from him. For after a caisson has penetrated more than 25 to 30 feet it is often not only impossible to get it back into its proper position, but it is also impossible to prevent it from getting more and more out with every foot of penetration, so that the utmost care and vigilance are required at the start.

A foreman who tries to keep his caisson right by means of a plumb bob or hand level, instead of from levels furnished by the engineers, will find it impossible to keep his caissons vertical and will be very much astonished to find how much he will be out of line and level.

Many accidents have happened to caissons which a little foresight would have avoided, as in numerous cases where the weight has been taken off, or not enough has been added to allow for the rising tide, with the result that the caisson almost completed has broken away from its bed and risen enough to necessitate its being completely wrecked.

In 1901 a break occurred in the intake caisson for the new Cincinnati waterworks. This was a very expensively designed caisson and one that the writer would not recommend being copied. The following report of the accident was furnished to the Engineering News by the chief engineer of the works at that time:

"The pump pit is on level ground, about 200 feet from the top of the river bank, and about 1,400 feet from the channel where the intake pier is located. The caisson rests on clean sand saturated with water, the shoe being at an elevation about 15 feet below the lowest point in the channel. The chambers of the caisson were filled with the same sharp sand in October, 1899, at a time when the river being low the air pressure required to keep water out of the working chambers was only about 15 pounds per square inch, which pressure was in a large measure counterbalanced by the weight of the sand ballast placed on the deck during the sinking process.

"The shaft connecting the pump pit with the tunnel was sunk immediately after the chambers had been filled; the portion of the shaft between the caisson and the rock being a cylindrical steel shell, lined internally with concrete and brick in Portland cement, and the same lining extending through the rock to the tunnel.

"This brick lining was built in November and the beginning of December, 1899, also a period of low water. The first high water after construction of the pit and shaft occurred on December 26, 1899. It reached 25.2 feet above datum. At the date mentioned an open seam in the brick lining of the shaft made its appearance, which was readily repaired by an injection of Portland cement mortar under compressed air.

"On January 26, 1900, a second freshet in the river to elevation 34.6 feet was attended with the same effect. A seam appeared again at the same place, and was repaired again in the same manner.

"On the occasion of a third rise, on November 30, 1900, elevation 42.3 feet, the same thing occurred again, but this time the seam showed itself about 10 feet below the first crack. In the meantime levels taken on the deck of the caisson from time to time had shown a deflection upward coincident with each period of high water. These deflections were permanent, indicating that the land had followed the roof of the chamber. It is quite evident that the open seams in the brick lining have been caused by the deflection of the caisson deck carrying with it the steel shell and part of the brick work below it, and that the same phenomenon will repeat itself with every stage of water higher than those preceding them since the execution of the work and until a sufficient weight has been placed on the deck to neutralize the effect of the highest water. For this reason it was decided not to repair the last crack until the pumping engines have been placed on the deck, as the weight of these engines will be equivalent to that of 25 feet of water in the pit, and as the last high water (elevation 59.6 feet) was only 11.4 feet below the highest water on record, we will then be secure against any further deflection of the deck.

"There is, in fact, no necessity for filling this crack other than the desirability of having a water-tight shaft on the rare occasions when the tunnel will be pumped out for examination."

To be fair, the above report has been copied word for word. Obviously the caisson should have been designed so that it would always be heavy enough to stay down, and this could advantageously have been accomplished by using less wood and more concrete. In fact, the design of this caisson made it an exceedingly expensive one to build, having a timber roof or deck 10 or 12 feet deep, and of oak, too, yet in spite of this excessive thickness the above report shows that the roof deflected upward. By using a modern thin (say 3 or 4 feet thick) yellow pine roof, and by using more concrete, the caisson would have been heavy enough to withstand the water pressure, especially if the working chamber had been filled with concrete instead of with sand.

In 1901, in sinking a crib for the Cleveland waterworks in Lake Erie, a steel working shaft 11 feet in diameter was used. The shaft was attached to the bottom of the caisson about 80 feet from the top, or at about the level of the bottom of the lake, and then extended downward for some 40 feet more.

During construction the air pressure was from 25 to 30 pounds per square inch, but at the time of the accident the pressure was supposed to be less.

Without warning the shaft broke in two at a point just above the bottom of the lake, where it was rigidly attached to the caisson, and the upper 80 feet shot up into the air, and in falling fell against the side of the crib, being too long to fall flat, which fact permitted the men to be taken out of the shaft uninjured—one man lost his life by falling down the shaft and four who were working below were drowned.

The fact that the shaft broke at what was apparently the bottom of the unsupported length, where the cantilever strain would be the greatest, would make it appear to be the result of a blow at the top, though a heavy wind storm might have had the same effect, and yet there were plenty of means at hand to have braced the shaft properly at little expense.

It is often difficult to make the men put in all the bolts in the flange connections and to see that they are all tightened up. Of course if a few bolts were missing and a slight blow was received at the top of the shaft, aided by a heavy wind, the accident could be easily accounted for.

There have been many causes for many kinds of caisson accidents, most of which could have been prevented with care. For instance, a large iron caisson broke loose off the coast of Nova Scotia and was carried out to sea, where it sank and was never heard of again.

In New York city most of the accidents have caused damage to the adjoining property, as well as to the caissons themselves, where by careless slacking of air, etc., material has been drawn from under the adjacent buildings, very badly wrecking them.

In one case the contractor or owner decided to save money by not using compressed air at all, and tried to sink five open cofferdams alongside of a twenty-story, nearly completed building, with the result that the building was undermined and was thrown 18 inches out of plumb. It was necessary to take out all the terra cotta floors and get a good firm of iron contractors to jack the steel work back to place. Needless to say, this cost more than good pneumatic caissons would have cost in the first place.

CAISSON DISEASE.

When a novice enters an air lock the pressure is, of course, at atmosphere, and as soon as the outer door is shut (it is usually held shut by the pressure of the air), the pressure is gradually increased; but no matter how slowly it is increased one has, at first, more or less trouble in equalizing the pressure on both sides of the ear drums. This is usually accomplished by closing the nostrils with a finger and thumb and then blowing the air through the throat into the ear passages. Sometimes beginners cannot do this, and occasionally even an old-timer will get caught this way if he happens to have a bad cold.

The result of getting "blocked" is that one or both ear drums may be ruptured, causing intense pain, or some blood vessel in the head may burst.

The most common complaint is known as the "bends," which only attacks one after leaving the caisson, sometimes several hours after, and thus tends to bear out the theory that caisson disease is caused by the air forcing the blood away from the surface and the bubbles of air remaining in the system when the person has left the air chamber too quickly.

The bends generally attack the arms or legs, and sometimes the lower part of the body, causing more or less intense neuralgic pains or cramps, which are said to resemble rheumatism, but to be worse. Yet, in spite of the intense pain and suffering, they rarely result in death.

The worse effect, however, is paralysis, which attacks the limbs or body, though generally the legs or lower part of the body. Sometimes the victim becomes paralyzed on the whole of one side. This trouble also, as a rule, attacks the unfortunate man shortly after he has left the compressed air, though sometimes not for several hours after. It is very rare for a man to be paralyzed while in the air chamber, though some have been killed the first time they have entered, and before they could get out.

Occasionally an old-timer, who has always considered himself immune, has been bowled over. When paralyzed, some completely recover after a few hours' treatment; some remain partly maimed for life, while others succumb sooner or later. Some experienced men claim that they can tell when they are going to get the bends or be paralyzed while still under compression, in spite of the assertion of other writers and experimenters that all forms of caisson disease are contracted during decompression.

Forty-five or 50 pounds above atmosphere is about the limit in which men have performed actual work, and these high pressures are always attended with great risk and loss of life.

French experimenters have shown that these pressures might be more than doubled safely, under ideal conditions; which, however, have not yet been attained in actual work. One of the chief conditions for thus working under a head of 200 feet depth is very slow decompression, but it is doubtful if men could do much work under such pressure without running too great risk.

Dr. Jaminet, one of the earliest to write on caisson diease, being the medical expert of the Eads bridge of St. Louis in 1871, came to the conclusion that caisson disease was simply the result of exhaustion from too rapid a tissue change caused by the absorption of excess of oxygen. His remedy consisted of a complete rest, with feet in an elevated position, and a supply of stimulants and nourishment.

A second theory, advanced by Dr. Andrew H. Smith, the surgeon in charge of the caisson work for the New York towers of the Brooklyn Bridge, was that the superficial pressure of the air upon the body acts to force the blood from the surface to the center, causing internal congestion. The more rapidly one enters and the longer one stays in compression, the worse this congestion, and the more rapidly one leaves the compression, the greater the danger of the blood not returning to its proper distribution, leaving more or less bubbles of air in the system and causing the bends.

A third theory is given by Dr. Wainwright, of the Waterloo and City Railway, London, and is to the effect that the blood and viscera absorb oxygen, nitrogen, and carbonic acid—particularly the latter—and that the physiological result of the carbonic acid gas and the mechanical action of all three gases in escaping through the tissues upon the release of pressure cause the bends.

I am inclined to think that there is much in all of these theories, and can set down established facts as follows:

1. The more rapidly one enters the higher pressures, the more rapidly the blood is forced from the surface, and the greater the risk of bursting blood vessels in the head or of fracturing ear drums.

2. The longer one stays in compression and the more work that is done, the greater the danger of being paralyzed or of getting the bends.

3. The quicker the pressure is reduced on leaving the caisson, the greater the danger.

4. I have known many cases where foul air did more damage than fresh air at a much higher pressure. Undoubtedly tallow candles in the early caissons and gas in the Brooklyn Bridge caissons, did much to knock the men out.

5. It is very dangerous to enter a compressed air chamber with an empty stomach.

6. It is advisable to put on warm clothing and take hot coffee on coming out if there is any danger of getting chilled.

7. The more energy expended in compression, the greater the danger. We know that the excess of oxygen in the compressed air renders the men very much more active than when in ordinary atmosphere, with a consequently greater fatigue.

8. It is suicidal for anyone with weak lungs, heart or nerves to enter the lock.

9. Even healthy people cannot be sure what effect compression will have on them until they try it.

10. The most reliable remedy is recompression in a hospital lock.

11. Electrical treatment is sometimes efficacious.

12. Most important of all, as much time as possible should be taken in decompression—the more, the safer.

Mr. Hersant, of the Bordeaux harbor works in France, made some very interesting experiments in 1895, in which he kept a man in a pressure of 768 pounds per square inch for one hour, taking 45 minutes to reach this pressure and three hours to reduce it.

From the result of experiments, the French doctors have suggested allowing 20 minutes for each 15 pounds of pressure for compression and decompression, which would be very hard to enforce for low pressures, as men are accustomed to only take five minutes, or even much less, to enter or leave caissons under pressure up to 30 pounds per square inch, in addition to atmospheric.

The risk increases so rapidly for every pound over 30 pounds that men are more cautious as the pressure approaches 45 pounds.

Another authority recommends 4 minutes for each atmosphere (15 pounds) for decompression below three atmospheres, and 10 minutes for each additional atmosphere above three atmospheres (45 pounds), but it is safer to stay out of anything above three atmospheres in addition to the normal.

I know from experience that the same remedy will not always have the same effect even on the same man; for instance, after suffering from the bends for several hours, I found that a hot cup of coffee produced a profuse perspiration and relieved the pain, which, however, quickly returned; so a very hot bath was tried, which also banished the pain until the bath room was left behind. Then complete relief was obtained from a few mild electric shocks. The second time I experienced the bends, a bee-line was made for the electric battery, which, however, failed to do me any good.

The first attack mentioned was in the leg and I noticed that every additional trip into the lock made the attack more severe; but on the second occasion, the attack this time being in the arm, it was found that by going in and out frequently but very slowly, the pain was reduced each time until it vanished.

Similar experiences make many think that they must "grin and bear it." But recompression in a hospital lock is now considered imperative.

In both of the above cases the pressure did not exceed 25 pounds per square inch, and yet I have experienced 35 pounds many times, and 45 pounds occasionally, without any ill effects. Like all diseases, a man is immune some days and liable to contract the ailment on others—and he can't tell which day is which!

In sinking caissons in the Harlem River we found that men suffered severely from the bends while passing through the foul silt and just below the bottom of the river, and that when this material had been passed through and the caisson had entered the clean (no sewage mixture) clay the trouble with the bends disappeared, although the pressure was necessarily very much greater.

In excavating there is always considerable escape of air under the cutting edge, etc., which, of course, has to be replaced by fresh compressed air which keeps the atmosphere in the working chamber in a fairly good condition; whereas, when concreting, after the concrete has covered the bottom above the cutting edge the loss of air is very much less, and hence less fresh air is received from the compressor, and the air becomes more and more contaminated as the concrete proceeds and the working chamber contracts, with greater danger of the bends and paralysis. Sometimes old-timers have gone in to uncouple the bolts in the upper sections of the shaft and in a short time have been taken out dead.

In one case, a rubber pipe caught fire and the compressor pumped the stifling fumes of burnt rubber into the working chamber, from which the men were with difficulty rescued.

When blasting in the working chamber, it is usual for the men to go out; but in one case where the working chamber consisted of several compartments the men walked into an adjoining compartment, out of the reach of any flying stones, etc., and after one of the discharges, one of their number was taken out dead.

BLOCK SIGNAL TRAIN-INDICATING.

THE EMERGENCY SAFETY EQUIPMENT IN THE EAST RIVER TUNNELS, NEW YORK.

The signal system is a development of that in use throughout the subway, and the changes from the older apparatus have been made largely on account of the reduced clearances. The signal apparatus designed more especially for these tubes will be used throughout on the Brooklyn extension and to a certain extent in the whole subway as replacement becomes necessary. The return of the direct-current operating the trains is by one rail only—the other rail of the track being divided by insulating joints into blocks of predetermined length for the signaling. The length of a block is that of two complete overlaps except toward the end of heavy up-grades, where the overlap is shortened. Thus the blocks vary from 800 to 2,400 feet. As in the subway, generally, lights only are used for signaling; red and green on the "home" signal for "stop" and "proceed," yellow and green on the distant signal for "caution" and "proceed" respectively. In the older subway signal-case the color of the signal is determined by a slide operating between a continually lighted lamp and a clear-glass lens. In the signal-case used in these tubes the color indication is given by separate color glass lenses in front of glow-lamps which are properly lighted and extinguished by auxiliary direct-current relays. A pair of 550-volt alternating-current feeders (No. 4, B. and S.) run the length of both tubes overhead. This circuit is run in duplicate to avoid possible interruptions. To these feeders are connected the primary windings of what have been called "track" transformers, located at each signal. These transformers have two secondaries; one with a 10 to 1 ratio of transformation, the other with a 50 to 1; the one gives current at 50 volts and the other at 10. The 10-volt secondary is connected across the rails at the beginning of this track section. Across the rails at the opposite end of the track section is connected the track relay, the moving element of which operates a contact controlling the direct-current relays (for lighting the signals) and the direct-current air valves for setting or releasing the train stops. This direct-current circuit is connected to mains extending the length of the tubes and is fed by 16-volt storage batteries in the Borough Hall and Bowling Green stations. A cast-iron grid of 1 ohm resistance is in series with the 10-volt track circuit at the transformer end of the section, and there is another similar grid at the relay end. These are to prevent excessive current, either alternating or direct (train-propulsion), in the signal circuits. A low-resistance impedance coil is placed in multiple with the alternating-current relay. Current for lighting the signal lamps is taken from the 50-volt secondary of the track transformer. The alternating current for the signal lamps is switched on and off by direct-current relays whose operating circuit is opened and closed by the track relay which is in turn operated by low-voltage alternating current from the rails. To insure the rapid dispatching of all these trains it was found advisable to give the Bowling Green operator control of signals and stops at both ends of both tubes. That he might know the progress of trains an automatic illuminated profile of the tubes was designed. It consists essentially of a box 4 feet long, 2 feet high, 1 foot deep, with a glass front and with a certain arrangement of interior compartments to represent the blocks of the tubes. All of the glass is made opaque, except the parts representing the tubes, which are subdivided by the walls of the compartments mentioned, so that each block can be illuminated independently of every other one. Each section is lighted by red or green lamps, according as relays are operated from the "home" signals at the different block points of the tubes. When a tube is clear this device shows a green line for that tube, and the position of train when in the tunnel is shown by having the particular block occupied shown in red. The interlocking switching plants are so connected that, in case it is desired on account of repairs, accidents, etc., trains can be sent through against the normal direction of traffic. After the Bowling Green operator has signaled the Borough Hall operator to send a train through in such reverse direction and after the train has entered the first block of the tube, then both interlocking machines are so locked that neither operator is able to change his signals or to send another train into the tube from either direction. When the train in question has emerged from the tube then the former conditions are restored and trains can be sent normally or against traffic, as before, at the judgment of the Bowling Green operator. At first it might be thought that a train could not be sent against normal direction of traffic on account of automatic stops, but in fact the train clears its passage ahead of itself in so running. Under normal running when a train enters a new block the "home" signal just passed and the one a block in the rear go to "danger," while the "distant" signal of the block two blocks back goes to "caution." The automatic stop at the entrance of the new block, however, remains down, the one a block back comes up and the one two blocks back goes down. In running against traffic on tracks so equipped then, the train automatically lowers the stop at the other end of the block entered and sets the one two blocks away. A 2-inch pipe line for the supply of air necessary to operate switches and automatic stops runs through each tube and connects with the Brooklyn and Manhattan stations, which have heavy, motor-driven air compressors. Smaller automatic motor-driven compressors have been placed at each end of the tubes for action in case the supply of air from both substations should be interrupted. The pipe lines carry a pressure of 75 to 80 pounds per square inch. Expansion joints of the common piston type are fitted to all pipe lines in the tubes about every 1,000 feet.—Engineering News.

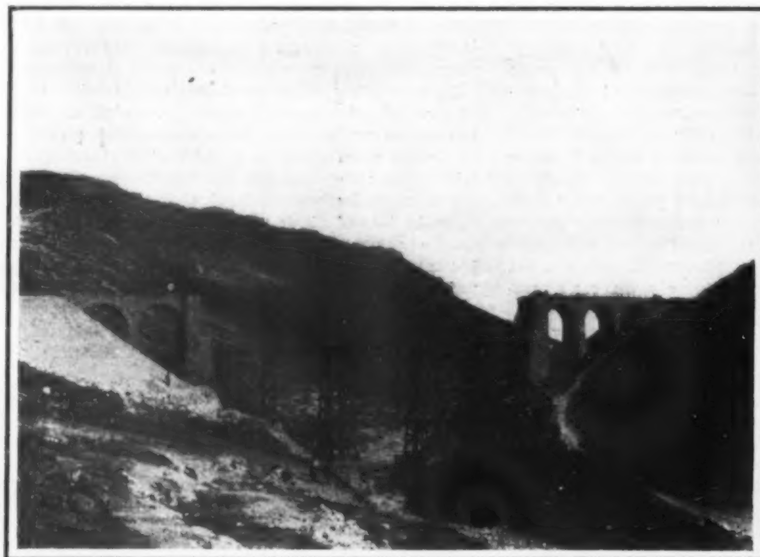
During the past year a commission of the Vienna Ministry of Commerce and Post Office have been investigating a proposal from the Siemens-Schuckert Works for the construction of an electrical underground railway, linking together all the railway stations and post offices in Vienna. Trains would carry letters, newspapers, and parcels through this subway at the rate of 32 kilometers (19 miles) an hour, and the cellars of the post offices could be enlarged and used as stations. It is said that the project, which at first was regarded as quite impracticable, is now viewed much more favorably. Investigations from the technical side show that there are no very great difficulties in the way there. And financially, too, there seem to be no very great obstacles, as the promoting firm is willing to build and equip the line entirely at its own cost, allowing the state to extinguish the debt by moderate annual payments. The advantages of the scheme would certainly be very great in facilitating the rapid handling of the mails, and also in ridding the streets of the numerous large and small mail vans now in service.

THE HEDJAZ RAILROAD.

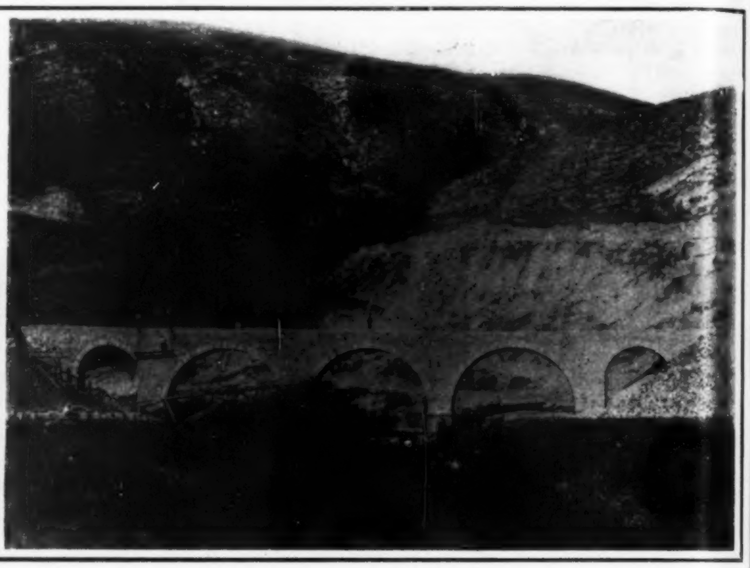
THE NEW SACRED LINE BETWEEN DAMASCUS AND MECCA.

BY THE ENGLISH CORRESPONDENT OF THE SCIENTIFIC AMERICAN.

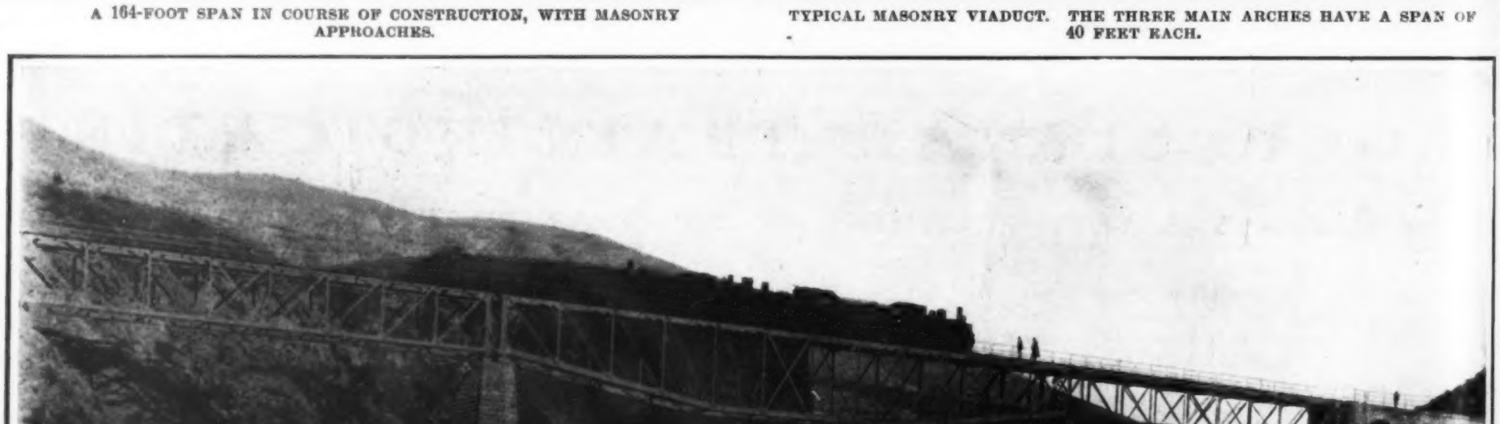
A few weeks ago there was inaugurated what in the eyes of the Mohammedan faith ranks as the most important railroad in the world, that extending from the city of Damascus in Palestine through the wild mountain ranges and expanses of the Arabian desert to the sacred cities of Medina and Mecca. Prior to European powers, the latter found the easiest and most simple means of bringing him to discuss terms was to threaten a blockade of Jeddah. Such a contingency would have seriously imperiled the Sultan's throne, since he is regarded by the faithful not only as their temporal but also spiritual ruler. The exist- built by the military, so that the cost of labor would be practically a negligible quantity; while the necessary funds, which could not be expected from the imperial exchequer owing to its bankrupt condition, were to be subscribed by Moslems. The Sultan issued a stirring appeal to his adherents, emphasizing the indis-



A 164-FOOT SPAN IN COURSE OF CONSTRUCTION, WITH MASONRY APPROACHES.



TYPICAL MASONRY VIADUCT. THE THREE MAIN ARCHES HAVE A SPAN OF 40 FEET EACH.



STEEL BRIDGE COMPLETED BETWEEN HEIFA AND DERAA, SHOWING MOUNTAINOUS CHARACTER OF THE COUNTRY IN UPPER PALESTINE.

Photographs by J. Halladjan, Haifa.

THE HEDJAZ RAILROAD.

the opening of the Suez Canal, the remarkable pilgrim traffic to these centers of sanctity was maintained *via* the overland route, and was attended by numerous grave dangers, of which attack and pillage by the marauding nomadic tribes infesting this country were the most to be feared. The completion of the Suez Canal opened a new route by the sea to Jeddah, whence the pilgrims proceeded afoot across the desert to the objects of their mission. This route offered the advantage of being more expeditious and cheaper than the overland Hedj track, and for the last thirty years has been generally followed. It, however, possessed one decided drawback from the Ottoman ruler's point of view. In his frequent diplomatic quarrels with ence of this weakness was realized by the numerous Moslem tribes of his Arabian subjects, and he was sorely taxed as to the most efficacious means of restoring his autocratic prestige. Supported by Izzet Pacha, then his favorite minister, he suddenly proposed to construct a railroad from Damascus to Mecca which would render him perfectly immune from European aggression, and which would afford an easy, expeditious, and cheap means of gaining access to the sacred cities whenever desired.

When first proposed the project was considered as absolutely impracticable by European engineers except at a fabulous cost, but here again the Ottoman ruler evinced conspicuous astuteness. The line was to be pensability of the railway and its complete solution of all the abstruse problems which had puzzled the administration for so many years in the establishment of the best independent facilities for enabling pilgrims to realize the one ambition of their lives, and the bounden duty of every member of the faith to support the scheme. The Sultan himself headed the list with a donation of $250,000, and this was soon swelled by subscriptions which poured in from every part of the world. In addition a special stamp tax was also levied throughout the Ottoman empire, which yields about $1,000,000 per annum. Strange to relate, every cent subscribed was devoted to the holy purpose in hand, and the construction of the Hedjaz railroad stands

unique in the annals of Turkish administration, in that bribery and corruption and personal appropriation were entirely absent. Moreover, the money was carefully husbanded and laid out upon the most economical system. By this combination of fortunate circumstances the line has so far cost only a little more than $15,500,000, or about $15,000 per mile.

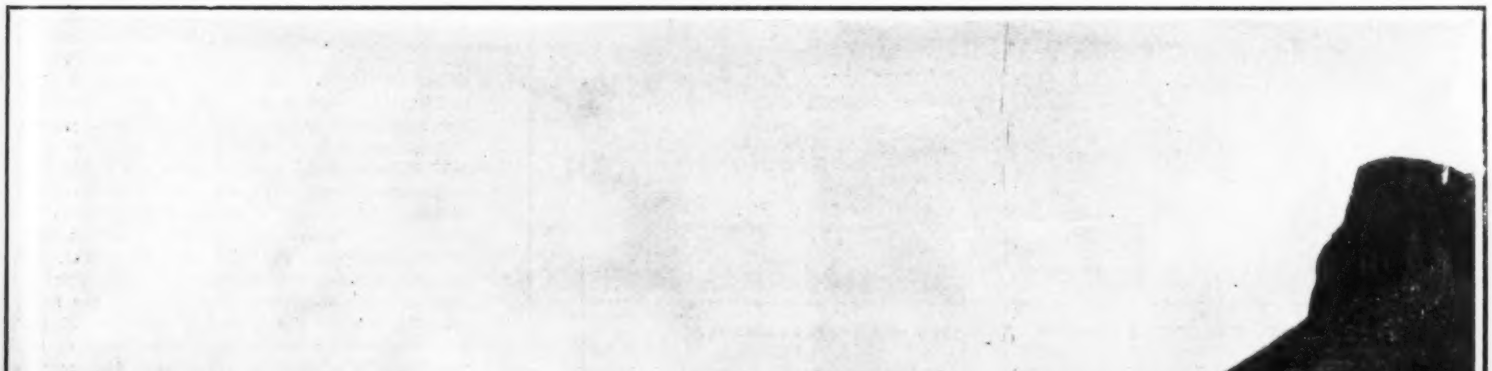
As an example of engineering skill the railroad stands pre-eminent among similar enterprises, even excelling the remarkable Trans-Caspian line, which has hitherto been considered the most wonderful piece of railroad construction ever completed. This is due to the fact that the route followed has been as direct and short as practicable, every obstacle apparently impossible of being surmounted having been overcome. The responsibility of the constructional work has fallen upon the German engineer H. Meissner Pacha, who as engineer in chief has personally superintended building operations at the railhead, subjugating difficulties as they arose at least so far as Medina Salah, the last important station before Medina is reached, which last link, in order to satisfy Moslem religious prejudices, was undertaken by a Mohammedan engineer, in accordance with Meissner Pacha's preconceived plans. We are indebted to the courtesy of Meissner Pacha for the publication of the accompanying illustrations, which afford a graphic idea of the magnitude of the task he has successfully fulfilled in almost record time. From Damascus to Medina a total length of 1,008 miles of line have been laid, and in this distance no less than four thousand bridges, viaducts, and tunnels have been built. The outstanding features of Meissner Pacha's constructional ingenuity are shown in the remarkable series of tunnels and bridges which carry the track through the valley of the Yarmuk between the Jordan and Deraa, the junction with the Haifa short branch, and his negotiation of the escarpment which at first arrested progress just beyond Akabat el Hajazieh, where the line after climbing the cliffs to over 3,700 feet above sea level makes a sudden descent into a yawning ravine.

Constructional work was commenced on August 31, 1900, the twenty-fifth anniversary of the Sultan's accession to the throne, and some four months after the scheme was first publicly suggested. Such energy is quite an exception to Oriental methods, and indeed the feverish haste with which the line has been pushed forward without sacrificing any of its strength is remarkable, remembering the characteristic Turkish dilatory methods. Damascus was selected as the northern terminus of the line, owing to its historic importance and position as an important commercial center in Palestine.

The route of the railroad follows broadly the path of the old overland pilgrim track, leaving the Dead Sea on the west and proceeding in an almost straight line to Ma'an in Arabia Petra. Ma'an is the first important station beyond Daraa, and is some 250 miles south of Damascus. It is already assuming the semblance of prosperity. Up to this point the line traverses one of the most fertile belts in the Ottoman Asian Empire, the land being well adapted to the cultivation of cereals.

After leaving Ma'an the line enters upon the mountainous country of Arabia. There is one continuous ascent to an altitude of 3,700 feet above sea level for a distance of about 40 miles to Akabat-el-Hejazieh along the crest of the tumbled cliffs. Suddenly this range of limestone terminates in a precipitous drop into the valley known as the "Devil's Belly." This is a wild ravine fringed on all sides by steep bluffs carved by Nature into the most fantastic shapes. To bring the line in a gradually descending grade to the floor of this gorge proved a difficult problem, and the ingenious method in which it has been accomplished will ever stand as a triumph of the engineering skill of Meissner Pacha, the engineer in chief. To make a detour in order to avoid the bluff was out of the question, as it would have involved too much expense and time, for the ridge extends 10 miles on one side and 30 miles on the other. To overcome the difficulty, the engineer resorted to what may be best described as a spiral descent. The line is carried parallel with one side of the bluff for a considerable distance clinging

THE MA'AN STATION, WITH THROUGH LINE AND SIDINGS.



Photographs by J. Halladjan, Haifa.

AMONG THE ARABIAN MOUNTAINS. THE RAILROAD LINE MAY BE SEEN AT THE RIGHT.

THE HEDJAZ RAILROAD.

to the rockside, with a grade of between 16 and 18 per thousand. Then it makes a sharp curve having a minimum radius of some 300 feet, continuing a series of windings until the bottom is gained. The ravine then gives place to an arid desolate plain, which continues all the way to Tebouk, the halfway station between Damascus and Mecca.

Tebouk is a spot of great sanctity to the Moslems, for here it was, according to their religious traditions, that the Prophet prayed one year after the first Moslem invasion of Syria was repulsed, and prophesied that what was then all barren and desolate should some day give place to a busy town. This promise, owing to the introduction of the railroad, is in a fair way of being realized. It is an important depot, though not so large as Ma'an, while owing to the remarkable fertility of the soil of the surrounding country, it will doubtless develop into a flourishing agricultural center. Water is abundant and easily obtainable. Within a few hours' journey to the west of the town are some remarkable archæological remains of bygone cities, which in the remote past were centers of great prosperity in Arabia, and to-day are especially famous for the abundance of extraordinary carvings and bizarre paintings which are there to be found.

The last depot before Medina is reached is midway between the latter point and Tebouk—Medina Saleh. This section of the line was carried through very rapidly, since the configuration of the country offered no insuperable difficulties. When Medina Saleh was reached the European engineers withdrew from the front, for it was feared that their presence as Medina was gained might inflame religious prejudices. Consequently, the task was handed over to Mukhtar Bey, an accomplished Moslem engineer, who on assuming control maintained the energetic progress in construction, with the result that the Holy Shrine was soon gained. Similarly, only Mohammedans were engaged in the building works upon this last-named stretch. They will be stronger against the attack of the recalcitrant Arabs, who may be fanatically disposed to embark upon plundering expeditions from time to time.

The rolling stock and locomotives are similarly of the most modern type. Owing to many of the grades being of great length and unavoidably steep, ranging up to 22 per cent, together with curves and counter curves of 300 feet radius, while some of the trains to be handled have a weight of 250 tons, many of the locomotives are particularly powerful. Among the types adopted is a powerful class of articulated compound Mallet engines built by Henschel & Sohn of Cassel, Germany, designed more especially for hauling the freight traffic. This locomotive has a very capable boiler with a heating surface of 1,780 square feet and a grate area of 27 square feet. The rails being relatively light and the gage narrow, it was necessary to have the heavy boiler carried upon six axles, the wheels of these being arranged in groups of three pairs each. The wheels of the rearmost group are coupled and placed in the main frame, which is rigidly connected with the boiler and driven by the two high-pressure cylinders. The second and third pairs of wheels of the front group are also coupled and are driven by the low-pressure cylinders. In front of these low-pressure cylinders a pair of truck wheels is fitted to allow of lateral play. This arrangement of the wheels permits the engine, though the total wheel base amounts to 28 feet, to travel around the curves of 300 feet radius with perfect safety at the maximum speed of 30 miles per hour. The slide valves are actuated simultaneously by Heusinger's gear, worked from the engineer's cab by screw and wheel.

The coupling of the bogie with the main frame has been effected somewhat differently from that hitherto followed in Mallet locomotives, namely, by means of a double joint, which insures a better movement on the curves and requires less lateral play on the truck. This coupling is arranged in the same manner as that between engine and tender. The oscillating movement of the front group of wheels, which hitherto constituted so disagreeable a feature in Mallet locomotives, has been reduced to a very small amount by fitting a spring actuating on two buffers. The engine is fitted with automatic vacuum brake operating upon all coupled and tender wheels, together with steam sanding apparatus and Coale pop safety valves.

Owing to the water being such a difficult problem, the tender had to be designed to carry 4,000 gallons. It is mounted upon four pairs of wheels, two each of which are united in a bogie. The following are the principal dimensions of this locomotive:

Engine.

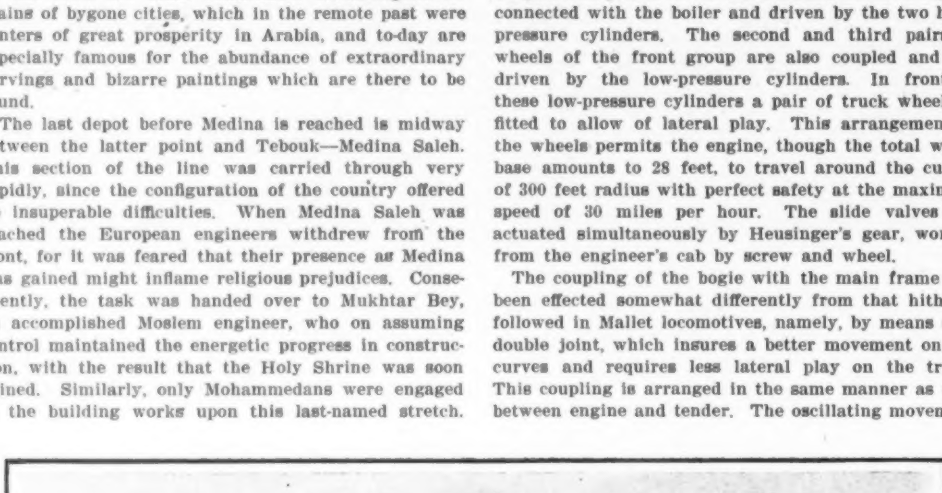
Diameter of high-pressure cylinders	12.625 inches.
Diameter of low-pressure cylinders.	20 inches.
Piston stroke	22 inches.
Diameter of coupled wheels	42.375 inches.
Diameter of truck wheels	28.375 inches.
Working pressure	170 lbs. per sq. in.
Heating surface of boiler	1,780 square feet.
Grate area	27 square feet.
Wheel base	28 feet.
Number of boiler tubes	200
Weight empty	45.75 tons.
Weight, working order, approximately	51 tons.

Tender.

Tank capacity	4,000 gallons.
Bunker capacity, approximately	5 tons.
Weight empty	14.5 tons.
Weight working order	37.8 tons.

The coaches are similarly of the most modern type, of the American pattern, well lighted and ventilated, and comfortably appointed.

At Damascus extensive works have been laid out covering some 13,000 acres, and equipped with the latest time and labor saving machinery and handling plant, so as to be capable of coping with any repairs that may be necessary to either rolling stock or the track, including also a commodious shop for the building of locomotives. At Haifa, which is rapidly developing into an important port, a spacious station has been erected, giving access to seventeen tracks and side tracks. Similarly, ample sidetracking facilities for freight and passenger cars are laid out at the intermediate depots of Daraa, Ma'an, Tebouk, and Medina Saleh.



MALLET COMPOUND FREIGHT LOCOMOTIVE FOR HEDJAZ RAILROAD.

Medina was reached early in August last, but the official opening of the railroad, which was carried out with much pomp and religious ceremony, was postponed until the anniversary of the Sultan's accession to the throne on August 31. The construction of the railroad and its branches was completed and it was opened for traffic within seven years—a feat which, considering the magnitude of the undertaking and the difficulties of the practically unknown country traversed, testifies to the energy which was evinced in the enterprise by all concerned.

The whole of the bridges, viaducts, and culverts are substantially executed in steel and masonry, adequate supplies of suitable stone for which were found immediately and easily available upon the sites. So far as possible, the spans and arches were standardized. The main steel spans are for the most part of 164 feet and the smaller spans of 98.5 feet, of the single-deck type. Arched masonry work has been extensively resorted to, both for the purpose of approaching the steel bridges and the viaducts. Owing to the deep character of the ravines through which the rivers flow and the necessity of maintaining the easy grading of the track, the bridges for the most part are very lofty. As far as possible, the piers were built clear of the water and of a heavy nature. In some cases the bridges were raised in advance of the railhead, so as to be completed by the time the track reached the water's edge, while in other instances a temporary line was laid across the river, so that supplies could be hurried up to the railhead, which was pushed forward while the bridge itself was under erection. At kilometer 239 an interesting double-decked masonry viaduct comprising ten arches of 20 feet span has been built. The upper level carries the railroad, while the lower deck serves as a highway for pedestrian and vehicular traffic. The stations are likewise of heavy and durable design, the buildings being carried out in stone, so that maintenance charges will be reduced to a minimum, while

The extension from Medina to Mecca is to be pushed on at once. The surveyed route will be 285 miles in length, making a wide sweep toward the coast. This last section will be built by Mussulman labor exclusively, under the supervision of Mukhtar Bey, the engineer who carried out the Medina Salah-Medina stretch. Two years have been sanctioned for the finishing of this last link, and the engineers are confident of accomplishing the work in that time. Already a large quantity of material has been acquired and sent down to Medina, where a depot is being established. It is estimated that this will entail a further expenditure of about $4,000,000. It is probable that when the whole railroad is completed and in working order, the Jaffa-Jerusalem line will be carried farther eastward, so as to link with this main line. At present only Moslems are permitted to travel from end to end of the line, Europeans being compelled to disembark at Tebouk. Possibly in the course of time religious feelings will be stifled, and no resentment be entertained against infidels traveling to and from a point nearer Medina.

A NEW GERMICIDE.

Consul Thomas H. Norton states in a report from Chemnitz that an important step forward in the prevention of bacterial diseases is due to the recent studies of Prof. Uhlenhut and Dr. Xylander, as just recorded in the Klinische Wochenschrift, and which he reviews.

These investigators find that remarkably successful results in the field in question are obtained by the use of antiformin. This is a trade name given to the alkaline liquid prepared by the addition of caustic soda to the familiar solution of sodium hypochlorite, known as Eau de Javelle, and used for years as a bleaching agent, for the removal of ink and fruit stains, and for moistening surgical bandages.

Antiformin is encountered in commerce as a clear, yellow liquid, with a strong but not repulsive odor, suggestive of both chlorin and caustic alkali. On account of the impossibility of isolating alkaline hypochlorites, solutions only can be prepared and used. For some time past antiformin has been used as a disinfectant, and especially in breweries for the purpose of cleaning rapidly and thoroughly vats and pipes.

The experiments of the two professors establish the fact that this compound destroys most effectively and rapidly the bacteria of dysentery, cholera, typhoid fever, diphtheria, and the bubonic plague. These germs are killed, when brought in contact for a few minutes with 5 per cent and even weaker solutions of antiformin. When a comparatively small amount of the powerful reagent is added to water containing the germs in question they gradually disappear, enter in fact into solution, very much as a lump of sugar would under similar conditions.

This property of antiformin renders it admirably adapted for the purification from bacteria of potable water, and for the complete disinfection of sewage and excrementitious matter. Experiments with the latter show that not only are all pathological germs present completely destroyed, but that also every trace of odor is removed.

Strange to say, the bacteria of tuberculosis show a remarkable power of resistance against the action of antiformin, so much so that it evidently will be of little aid in connection with the world-wide crusade now being waged against that disease. There are, however, many indications that antiformin will be of pronounced value in connection with the developments in the rapidly widening field of serum-therapy.

Primary solutions of sodium hypochlorite have ordinarily been prepared by triturating bleaching powder (calcium hypochlorite and calcium chlorid) with water and adding a solution of sodium carbonate by passing a current of chlorin gas into a solution of the latter salt, or—most economically—by passing chlorin into a mixture of caustic lime and sodium sulphate.

Solutions of sodium hypochlorite are now prepared in Germany by the electrolytic decomposition of 5 per cent salt solutions in platinum troughs. A current of 110 volts and 100 amperes furnishes in such an apparatus nearly 6,000 liters daily of a bleaching solution containing 1 per cent of available chlorin.

Blanc de Gorge is used for repairing, also for painting over defective spots in porcelain. This flux, which is melted in the muffle and combines with the permanent glaze, consists of 3 parts of quartz sand, 5 parts of melted borax, and 9 parts of red lead. The mixture is melted and then finely ground.

THE SEASONAL ACTIVITIES OF PLANTS.

FACTORS AFFECTING DEVELOPMENT AND DISTRIBUTION.

BY DR. D. T. MACDOUGAL,

DIRECTOR OF THE DEPARTMENT OF BOTANICAL RESEARCH, CARNEGIE INSTITUTION.

EVERY species of plants inhabits the areas which it has been able to reach and occupy from the starting point of its place of origin. Neither its birthplace nor any of the places within its range may offer the most suitable conditions for the best growth and highest development. Beyond seas, over mountain ranges, across the equator, or past other equally effective barriers, may lie plains, valleys, plateaus, or even continents, where if once introduced it might overbear all competition from the plants already there, extending its distribution a thousandfold and the number of its individuals a millionfold.

The forces or factors which determine whether or not a plant may enter into and occupy any new region are simply physical properties capable of ready apprehension and easy measurement. The soil, its chemical and physical properties, light, the course of the temperature, moisture supply, and food material are the most important of these.

It will be impossible to give even a brief consideration of the special relations of each of these factors to the plant, but we may gain an insight into their general character by a consideration of the more important details with respect to temperature, which is one of the most widely interlocking elements of climate. The general conclusions derived from its consideration may be held to apply to other agencies as well.

We know by every-day experience that there is a certain general degree of heat at which any given species grows best; and a discrimination as to the application and regulation of temperature constitutes one of the most important features of the practice of greenhouse gardening. This temperature, which is customarily termed the *optimum*, may be ascertained to within a degree or two very easily. If the heat be increased in a greenhouse in which a plant is happily growing at the optimum, it will soon be found that such increase lessens the rate and amount of growth and a continued increase will soon bring the thermometer to a point where a *supra-optimum* will be reached, at which growth ceases. This may simply bring the plant to rest, as might the cold of autumn, and with but slight damage. But if the heat be increased still further, a third point will be found at which the plant is killed, and by such a test we shall have ascertained the point of fatal heat.

Starting again with a plant at the optimum, it will be found that as the temperature decreases, growth slows down until an infra-optimum is reached, at which growth ceases as it did at a certain point above; still below this is the temperature of *fatal cold*, at which living matter is totally disorganized.

Our efforts at acclimation and our work in securing the feature of hardiness in plants, with respect to temperature, consist in operations by which the position of the cardinal points of the plants with which we may be working may be altered on the scale of the thermometer. These cardinal points undergo wide changes in a state of nature, and it is by taking the inherited capacity for adaptation of any plant with regard to this particular into account, that we may hope to make our greatest progress.

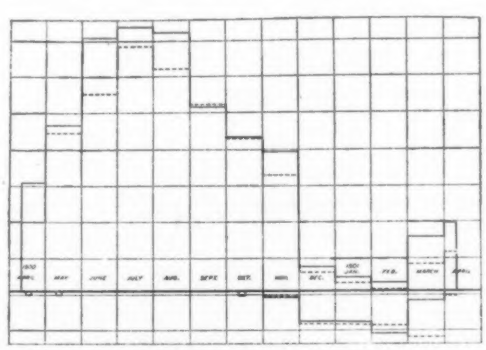
This brings us at once to the consideration of the practicability of some estimation of the thermal constant of any form, or the amount of heat necessary for its seasonal activity or cyclical development.

In order to make rational effort in the acclimation of plants to any given region, it is necessary to consider first the practicability of some estimation of the thermal constant of the plant itself, as well as to estimate the total amount of heat furnished by the locality in question. Many empirical methods have been devised for this purpose during the last two centuries, but none has yet been found easily applicable, or of any wide usefulness. To meet this need I have at last come to a method which has been evolved as a result of studies extending over a decade, in which the thermal constant of a plant is calculated in such manner that the number of hours to which it has been exposed to temperatures above the freezing point after the winter solstice, or from the time of the sowing of the seed until flowering, or fruiting, or any other developmental stage has been reached, is found, and this factor is applied to the height of the thermometer above the freezing point during the period mentioned.

In actual practice this may be easily done by computing the area inclosed by a thermographic tracing of the temperature and the base line of the sheet for the period over which the development of a plant is to be studied by means of a planimeter. It was found by this method that the flowers of *Acer saccharinum* were mature and ready for fertilization on March 26, 1901, in the New York Botanical Garden, after 1,100 hours' exposure to temperature above zero with a totality of 3,209 hour Centigrade units. *Draba verna* attained the same stage something earlier in 974 hours with 1,644 hour Centigrade units exposure.

Now it is by no means to be assumed that the above data represent the fixed and invariable constant heat exposure of the plants in question; for as has been described previously, the cardinal points, including the optimum for growth and development, may be altered by other conditions which affect the plant. The variation of which a plant is capable represents its possible geographical range, which may be mapped with fair accuracy. Thus the individuals of a species which live nearest the pole have made such accommodations that they are able to accomplish development with a minimum number of heat units in a minimum number of hours. As the range of a species is traversed toward the equator or to lower elevations, a place is reached where the heat exposures are at an optimum for the plant, and beyond this development is retarded until the southern limit of the species is reached. The actual limits are of course determined by the entire complex of conditions, of which insulation is also an important factor, but for the sake of clearness attention is focused upon temperature alone.

The relation of the plant to exposure below the



THE SEASONAL ACTIVITIES OF PLANTS.

Temperature in New York Botanical Garden. The proportionate number of hour degrees of heat in the open herbaceous grounds and in the hemlock grove respectively are shown by the solid black and the dotted lines.

freezing point is one of endurance, and the interpretation of the influence of such low temperatures may not be made by the formula described above. The total amount of negative on cold exposure is undoubtedly the predominating one in discussing the northward extension of a plant; but the minimum, the range in variation, and the occurrence of minima below the freezing point during the vegetative season, are also of importance in distribution, and await additional data before their interpretation may be attempted successfully. Some of these factors are extremely localized, and the poleward limit of distribution in the northern hemisphere of many species is known to run in extremely irregular lines.

Having thus taken the measurement of the capacity of the plant, it is possible by the same method to make an estimation of the conditions furnished by a locality by the use of the same method. Thus from the results of the comparative study of the climate in the hemlock grove of the New York Botanical Garden and the meadow of the herbaceous grounds, not more than 500 yards distant, made in 1900 and 1901, the data obtained show that the meadow carpet received 78,836 hour-degrees of heat during the year ending April 1, 1901, extending over 7,282 hours of exposure to temperatures above the freezing point, while the hemlocks received but 68,596 similar units of temperature. The meadow was exposed to 5,569 units below the freezing point, and the hemlocks to 5,791 units. The herbaceous grounds were below the freezing point for 1,478 hours, and the hemlocks for 1,736 hours. (See diagram.)

Still another important phase of the question is to be taken into consideration, namely, the stimulative reactions and conditions of which the plant is capable. Briefly stated, a sudden change in the temperature, or in any of the forces acting upon a plant, may constitute a stimulus which may awaken some function or activity previously dormant. A familiar illustration of this is to be found in the awakening of resting bulbs by bringing them into a warmer room for sprouting. It is not to be supposed, however, that these stimulative changes consist only in alterations from low to high intensities. Thus *Encelia farinosa* is a desert shrub which springs into activity during the cold winter rains of February in southern Arizona at altitudes of 2,000 feet, and with the approach of the warmer weather, of the dry fore-summer, goes into a resting condition. If at this time plants are placed at an altitude of 6,000 feet, the low temperatures at once awaken it into a new activity. A parallel action is exhibited by the seeds of these winter perennials, as they are termed. These are cast on the ground and lie dormant during the high temperatures and rains of summer, only beginning to sprout several months later under the stimulation of temperatures between 30 deg. and 40 deg. F., as recently discovered by Prof. J. J. Thornber.

An interesting set of data has recently been obtained by Dr. B. E. Livingston with respect to the change from the infra-optimum to the optimum with regard to moisture, from which it is seen that seeds of *Cereus*, *Fouqueria*, *Phaseolus*, and *Triticum* germinated when transferred from an air-dry condition to soil containing 15 per cent of water, *Impatiens* in soil containing 20 to 25 per cent, and *Trifolium* at 25 per cent moisture.

In contrast with these more or less vivid stimulative reactions are the accommodative and adaptive responses made by plants when the intensity of external conditions undergoes slow and gradual changes. The amplitude of such changes, and the degree of accommodation of which any plant is capable, are a true measure of its capacity of being acclimated. The more extensive studies upon this subject have been concerned with the northward extension of the cultivation of fruits and cereals, and are embodied in the history of horticulture and agriculture.

So important are the possible results in this phase of experimentation held to be, that the Department of Botanical Research of the Carnegie Institution of Washington has established stations, under permits from the management of the National Forest, at 8,000 feet in a moist Alpine climate, and at 6,000 feet in an arid situation in the Santa Catalina Mountains, in connection with a small experimental farm at 2,200 feet in the alluvial irrigated soil of the Santa Cruz Valley near Tucson. Without going into detail at this time, it may be stated in general that the experimental work carried on at these plantations involves an interchange of plants among the three stations, and also introductions from various locations in different parts of the world. In the two seasons that have elapsed since organized, ample reward has been obtained for the effort expended.

The methods and the results discussed above refer wholly to adaptive or responsive changes made by the bodies of plants subjected to any given environment, and forming accommodations to it. These alterations are of the greatest importance in the extension of the range of any plant, and by a study of them the accommodation response may excite the plant to increase the very feature of its structure of economic importance, and suppress those useless or harmful in its application to our needs.

Still a last possibility is to be taken into account in the great change to which plants are subjected in acclimation work. I have recently demonstrated that external agencies may be made to act upon the germ cells of plants in such manner that changes take place which are expressed in the progeny, and are heritable from generation to generation, constituting in fact the origin of new forms having the standing of species.

The experimental methods used are fairly simulated by natural forces. It is to be said, therefore, that in taking plants from their native habitats to the uttermost extent of their possible ranges, we may subject them to forces which may be a most potent factor in the origination of new qualities and new lines of heredity, not by direct adaptation, but by the response of the germ protoplasm to the direct action of environmental factors on the egg or pollen cells.

Gray-Black Stain for Iron.—In 100 parts of water dissolve 2.5 parts of chloride of bismuth, 5 parts of sublimate, and 2 parts of chloride of copper. To this add 10 parts each of hydrochloric acid and alcohol. It is applied in the usual manner. The object, as is always required in such operations, must be thoroughly cleansed. After drying, the objects are placed in water which is kept boiling for half an hour.

THE SANITARY CEMENT BLOCK HOUSE.

ITS USE IN THE TREATMENT OF TUBERCULOSIS.

Dr. Charles Denison, of Denver, exhibited before the International Congress on Tuberculosis, recently in session in Washington, a model of a house constructed of hollow cement blocks, with cement roof tiles or shingles, and reinforced concrete floors. There are no wooden casings for windows or doors. The window sashes slide into the walls, so that the entire area of the window can be thrown open. The floors and ceilings are "coved," that is, they join the walls in smooth curves, not in sharp angles which collect dust and vermin.

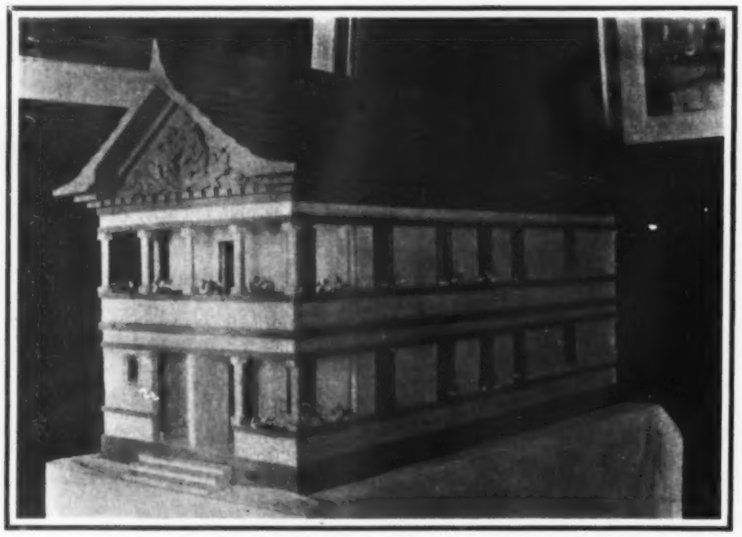


Fig. 1.—MODEL HERE SHOWN IS THE DOUBLE FIVE-ROOM APARTMENT STYLE. IT CAN BE BUILT CHEAPLY AND IS MORE SANITARY THAN THE USUAL STRUCTURE.

Responsible contractors or cement-block makers have estimated the costs and agreed to build the full-sized 24 x 56-foot double house, here represented in the model, for from $500 to $1,000 less than the present price of a brick or stone and wood house of the same character, i. e., for approximately $5,000.

Experts on concrete construction have examined this model house and have pronounced it both feasible, practical and inexpensive. Messrs. Fallis & Stein, the architects of the new concrete "Ideal Building," in Denver, have estimated the cost of construction to be $300 less than a similar house in wood and pressed brick which they are building.

Fig. 3.—WINDOW OPENING OF DR. DENISON'S "SLEEPING CANOPY," OR TENT IN THE HOUSE.

A substitute for porch-sleeping, here used to illustrate the sliding of windows and screens on ball-bearing castors into the walls.

The scale of the model is 1 to 16, or ¾ inch to the foot.

There are approximately 2,300 blocks or pieces in this house as represented in the model. The illustration of the ceiling molds, made with their carved edges in sheet metal, to make cove ceilings, is shown in Fig. 2.

The reinforced floors, with the reinforcement shown anchored into the special course blocks all around the building, can be imagined to illustrate the reinforcement of the rafters, which is not here shown. But the binding of the sides of the house together "as firm as a rock" at the floor level is secured by this method of reinforcement of thė floors.

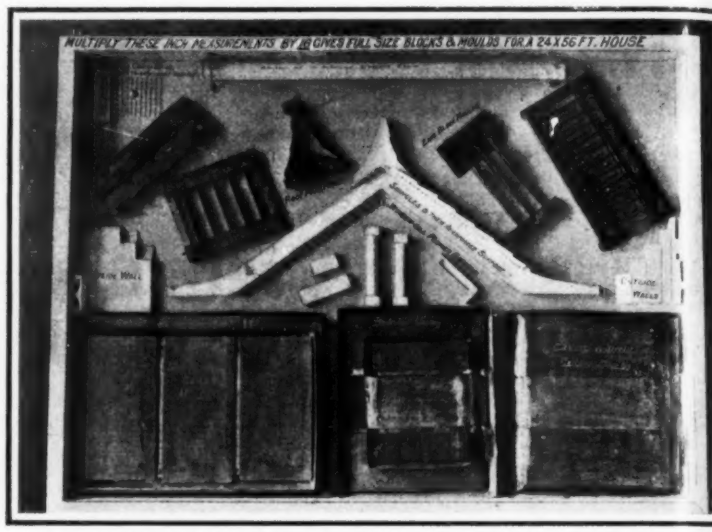


Fig. 2.—THE MOLDS, BOTH CEILING AND BLOCK MOLDS, WITH FORM OF ROOF AND REINFORCED FLOOR CONSTRUCTION USED IN BUILDING THIS MODEL

The cement shingles are here imbedded in the cement spreading on wire screening, but could be fastened in place in many other ways; in fact, the ornamental roof could be made of terra cotta and wood, if desired, without changing the cement character of the house below.

The shape of the blocks, both the hollow outside and hollow inside wall blocks, the blocks in course, the window sill flower garden blocks, the columns, the eave and peak blocks, can all be seen in Fig. 2; while Fig. 4 is sufficiently suggestive of the possible other forms of construction, all on the same general plan, that is, the same outside wall and inside wall blocks are used. The same ceiling molds, when once made (and they need not be expensive) will answer for any number of houses, and the same kind of reinforced floors and roof parts are used.

The chief feature of this method of construction is to be carried out in all these suggested modifications of the plan shown in the model; and that feature is the double ventilation by running the windows into the wall, and the arrangement of sleeping rooms in connection with open porches so as to have always afforded the possibilities of outdoor living and sleeping.

The construction of the house is based on the rule of minimum ventilation proposed by the designer, namely, that there shall be 2,000 cubic feet of air space per person, renewed once per hour, a complete hourly refreshening of a room's atmosphere through an external opening one foot square being the method of renewal. This is a liberal reckoning, according to Parkes and similar hygienists. Below this minimum limit, to practically insure against tuberculosis infection, houses should not be allowed to be built.

By this rule, the 1,000 cubic feet bedrooms in this house have each a possible renewal capacity of once in eight minutes for two persons. With both the doors and windows open conditions equivalent to outdoor living are possible here, even when there is no wind. The construction here shown (i. e., in the model) is in the two five-room apartment style, but may be built in the single, duplex, triplex or quadruplex form, as shown in plan A. It may be modified to a double seven-room house of two stories, as in plan B; a 22-room house of three stories, as in plan C; or a 30-room sanatorium or boarding house of four stories, as in plan D. All styles may be made under the same kind of a roof and with the same kind of molds. The building is entirely of concrete blocks, with reinforced floors and rafters, all made on the moist plan.

The windows are made to disappear completely into the hollow wall, thus giving twice the amount of ventilation possible with the ordinary window which slides up and down. Ball bearings placed at the top and bottom of the windows make them extremely easy to operate. The screens work on the same principle.

By placing beds beside the windows (whether or not covered with a canopy as shown in the model), the good effects of sleeping out of doors are produced.

The special sanitary features are: It is fireproof, bugproof, and ratproof; its bright cove ceilings reflect light, and its ventilation is on a basis of possible renewal of air superior to ordinary houses with the same sized rooms.

The borders of the cement floors are built up on a one-inch radius "sanitary cove," so that no dust, filth or vermin can collect in those corners.

The house is warm in winter and cool in summer. It is intended to be heated by warmed air conveyed from cellar furnace to air ducts in the partition walls and distributed as needed to each room. Heating by stoves, using these air ducts for chimneys, or by a hot water or steam system, is possible, the latter through pipes placed in these hollow walls during construction, the same as is intended for the plumbing and sewage pipes to the bathrooms and kitchen and for ventilation flues or tubes to the ventilated attic.

There are individual front and rear openings for each apartment, and the cellar is to be divided for the accommodation of all families.

The cost of construction compared with that of brick and wood houses of like size and convenience, varies

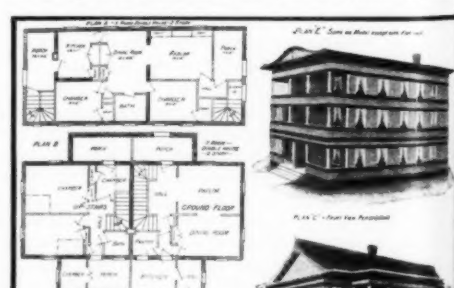


Fig. 4.—SAMPLE FLOOR PLANS AND HOUSES POSSIBLE WITH THE SAME SIZED CEILING AND BLOCK MOLDS, AND UNDER SAME SIZED ROOF.

according to local conditions, the price of labor, skilled or unskilled, the cost of Portland cement and the supply of material—sand and conglomerate.

With the forms and directions provided the owner of the ground, though unskilled in architecture, may build the house himself. Or he can buy most of the blocks purposely, or already, made by cement block

manufacturers for from $18 to $50 a hundred, according to their size and weight, made on a basis of 1 of Portland cement to 5 of sharp sand, and then put up the house himself.

For the working class, beauty and elegance may be sacrificed to equal utility by leaving off the ornamental roof and extending the top floor ceiling, sloped each way from the center on its upper surface, like a cement sidewalk, to carry off water (see Plan E); also, by rough calcimining or painting the inside walls as built.

For economy, too, the cost of heating is lessened by the concrete construction and by smaller sized rooms, rendered feasible by this superior system of ventilation.

On the hard finished interior walls, housecleaning, whether dry (compressed air) or wet (by hose spray or scrubbing) is simplified and made easy by the absence of door and window casings. At the same time, inexpensive ornamentation and pleasure is afforded by the window sill flower sinks around each apartment.

A maximum of sunlight, air ventilation, and out-door comfort is afforded by the open front and rear porches, as well as by the windows, which may be made as high and large as will leave sufficient space in the walls for the disappearance of screens and sash.

ULTRA-VIOLET RAYS.

THEIR CHEMICAL AND PHYSIOLOGICAL EFFECTS.

BY DR. LUDWIG GUNTHER.

Beyond the limits of the visible spectrum of the sun and many other sources of light and heat are non-luminous rays of two kinds—infra-red and ultra-violet. The former were discovered in 1800 by Sir William Herschel; the latter by Carl Ritter in the following year.

The infra-red rays are characterized by the posses-

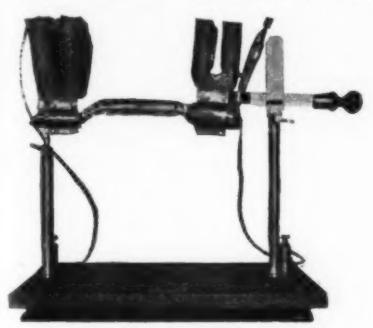


Fig. 1.—HERAEUS MERCURY VAPOR LAMP.
The tube is kept cool by the metallic plates at its ends.

sion of much energy and the production of a corresponding amount of heat when they are absorbed. Hence they were long known as heat rays or thermal rays. The ultra-violet rays were called chemical rays, because of their great power to produce photographic and other chemical effects. They also discharge electrified bodies and induce fluorescence and phosphores-

Fig. 2.—KROMAYER'S FORM OF THE HERAEUS LAMP.

cence, by means of which they manifest themselves to the eye. In recent years our knowledge of ultra-violet rays has been greatly advanced by the researches of Cornu and Victor Schumann, by the construction (especially by Zeiss) of lenses and apparatus suited to their investigation, and by the invention of the Uviol mercury vapor lamp and other lamps which emit these rays in great abundance. We possess in the photographic dry plate an optical instrument of an astonishing sensitiveness, which reaches its maximum in the blue-violet region of the spectrum and extends far into the ultra-violet. Silver iodide is even more sensitive than the bromide to ultra-violet rays, and by its employment Schumann has traced the rays to a wave length of 100 $\mu\mu$. (The symbol $\mu\mu$ denotes one-millionth of a millimeter.) The wave length of the yellow-green region which appears brightest to the eye is 560 $\mu\mu$. The study of ultra-violet rays was greatly retarded by the fact that they are strongly absorbed by ordinary glass. All lenses and prisms used in working with these rays must be made of quartz or of fluorspar, which are almost transparent to them. The transparency of quartz extends to a wave length of 220$\mu\mu$, beyond which point

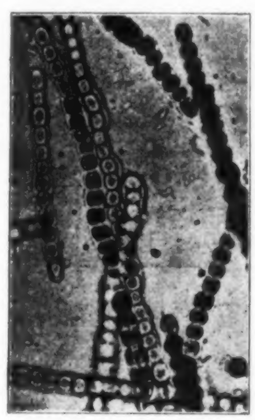


Fig. 5.—BLUE ALGAE PHOTOGRAPHED BY ULTRA-VIOLET RAYS.

flourspar must be employed. The firm of Schott & Co., of Jena, which produces the fused quartz of which the Zeiss lenses and prisms are made, also manufacture a special glass, called "uviol" glass, which is fairly transparent to ultra-violet rays and is used in mercury vapor lamps and for other purposes.

Chemical effects are not confined to the violet and ultra-violet rays. Every part of the spectrum exerts a chemical action peculiar to itself, and orthochromatic photographic plates (that is, plates sensitive to all colors) are made by adding certain dyes to the silver bromide emulsion. This peculiar power of dyes to sensitize other substances for those rays which are absorbed by the dyes is also shown in the "photo-dynamic" phenomena studied by Von Tappeiner and Jodlbauer. Ferments which were not ordinarily affected by green light, for example, were strongly

Fig. 3.—NUCLEUS OF EPITHELIAL CELLS OF SALAMANDER PHOTOGRAPHED BY ULTRA-VIOLET RAYS.

affected by it after treatment with certain red dyes. But the so-called "chemical" rays determine the most numerous chemical transformations and the most violent reactions, for example, the explosive combination of chlorine and hydrogen.

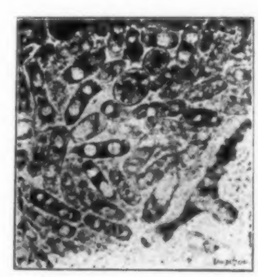


Fig. 4.—YEAST CELLS PHOTOGRAPHED BY ULTRA-VIOLET RAYS.

The recent researches of Krüss have shown that the absorption spectra of many colorless substances show characteristic bands in the ultra-violet region. Among these substances are the "leucobases," which result from the deoxidation of certain powerful dyes, such as those of the triphenylmethane series (malachite green). The spectra of these dyes show characteristic absorption bands in the visible spectrum and other

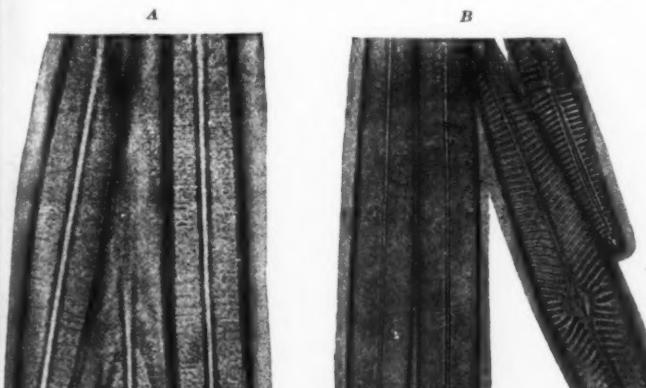


Fig. 6.—SECTION OF A DIATOM (AMPHIPLEURA).
Magnified 2,000 diameters and photographed. *A* by violet light, *B* by ultra-violet rays.

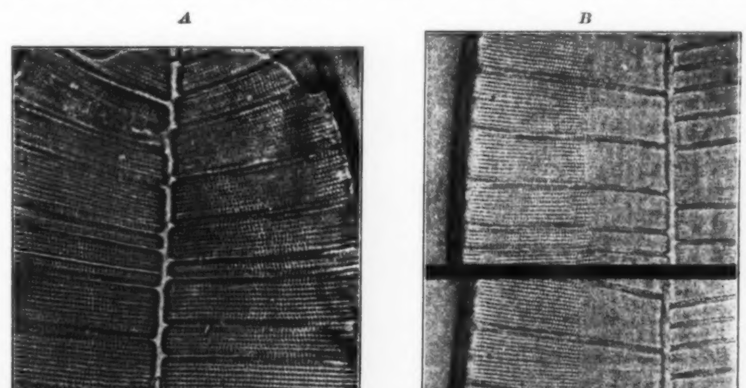


Fig. 7.—SECTION OF A DIATOM (SURIRELLA).
Magnified 2,000 diameters and photographed. *A* by violet light *B* by ultra-violet rays.

and equally definite bands in the ultra-violet. In the spectrum of the corresponding leucobase the first group of bands is wanting, but the bands in the ultra-violet remain. The wave lengths of the invisible bands are approximately half those of the visible bands. In some cases both groups are visible, the first in the red, the second in the violet.

Ultra-violet rays are of great importance in photography, and in some cases they may be employed alone with advantage. Thus, according to Wood, the shadows of landscapes may be softened by the employment of ray filters of aurin and nitroso dimethylanilin, which transmit the ultra-violet but stop the luminous rays.

A part of the ultra-violet and ordinarily invisible region of the spectrum becomes visible, as pale lavender, if all other luminous rays are carefully excluded from the eye.

The physiological effects of exposure to ultra-violet rays are very marked, so that in some methods of radiotherapy lamps which emit only waves of short length are employed. The best adapted for medical use are the Heraeus mercury vapor lamp (Fig. 1), in which the tube is made of fused quartz, and Kromayer's modification of it (Fig. 2), which can be applied directly to the affected part, to which the rays pass through a small window of quartz. Schott's "uviol" lamp is less effective, owing to the imperfect transparency of the "uviol" glass for ultra-violet rays, but it is much cheaper and is well adapted for technical use in cases where prolonged radiation is desired to accelerate chemical processes or to test the permanence of dyes and fabrics under exposure to light, for which purpose long and costly experiments under southern skies were formerly required. Ultra-violet rays have even been used to shorten the process of making patent leather. Ultra-violet rays of definite wave lengths can be obtained from spark discharges between electrodes of magnesium, cadmium, or an alloy of cadmium, zinc, and lead.

Ultra-violet rays have proved their efficacy in the treatment of various morbid growths. Finsen's discovery of the remarkable healing power of light led to the employment of this agent in diseases of all kinds, to false hopes, disappointments, and some accidents, for ultra-violet rays, like X rays, are capable of causing very serious injury. Yet in a few years many cures have been effected. Lupus or tuberculosis of the skin, tetter, and similar diseases, if not too far advanced, can be healed, but the future must decide whether superficial cancers can be cured by ultra-violet rays. The hope that these rays may be more extensively and successfully employed in the cure of disease is encouraged by their destructive effect on the lower vegetable and animal organisms. They not only destroy bacilli, but they kill flies placed near a mercury vapor lamp.

In microscopy a new field has been opened by the employment of ultra-violet rays. The resolving power of a microscope is inversely proportional to the wave length of the light employed for illumination, for it is impossible to form an image of an object of dimensions smaller than half that wave length. This law was discovered by Abbé and Helmholtz, independently of each other, in 1873. The time was not then ripe for the employment of the very short ultra-violet waves. The wave length of the light incident on the object was shortened by immersing both object and object lens in a liquid of high index of refraction. By this expedient a wave length considerably shorter than the 550 $\mu\mu$ of the brightest rays of daylight in air can be obtained. By the employment of blue light the resolving power was still further increased. The final step, which has now been taken, is the employment of non-luminous ultra-violet rays. This involves many difficulties which have been overcome by the patient labor of Koehler, working in conjunction with the two Jena firms we have already mentioned.

The new apparatus is very similar to the Zeiss apparatus for microphotography with ordinary light, but all the lenses are made of rock crystal. The source of radiation is a series of sparks formed by the discharge of a Leyden jar between electrodes of cadmium or magnesium. Only one line from the spectrum of either metal is used, giving a wave length of 275 or 280 $\mu\mu$. The object to be photographed is focused by ordinary light, then the eyepiece is replaced by another which contains a screen of uranium glass, and the focus is adjusted for the ultra-violet rays, which are made visible by fluorescence, and finally the camera is substituted for the fluorescent eyepiece.

The quartz lenses are not achromatic, but as only rays of a single definite wave length are employed, all these rays are brought to one focus, that is, the optical system is practically "apochromatic." But as the lenses are not corrected for dispersion, the focus varies with the slightest difference in wave length. For example, a certain spectral line could not be employed, because it really consists of a pair of lines. Three types of quartz objective are used: one dry combination and two glycerine immersion systems. These objectives, used with five different quartz eyepieces, give powers ranging from 200 to 3,600. The highest power is nearly thrice that of ordinary microscopes.

The microphotographs herewith reproduced give an idea of the resolving power of the new instrument. Living yeast cells (Fig. 4) show a profusion of hitherto unknown detail. The lens of the eye of a triton larva was found to be entirely opaque to ultra-violet rays—a discovery which suggests an explanation into the body. The new method has been applied the human epidermis are also nearly opaque to the rays, which fact explains their small power of penetration into the body. The new method has been applied to the study of bacteria and blood corpuscles. It reveals characteristic differences between the corpuscles in health and in malaria and leucæmia, and shows that blood corpuscles are irregular masses without the cellular structure which they have hitherto been supposed to possess.

Microphotography with ultra-violet rays has thus already rendered valuable service to the biologist, and there is good reason to believe that it will prove equally useful to the geologist, the mineralogist, and the metallurgist.—Translated for the Scientific American Supplement from Umschau.

SOME ASTRONOMICAL FALLACIES.

FACTS NOT MENTIONED IN BOOKS.

BY J. E. GORE, F.R.A.S., M.R.I.A.

The following astronomical facts and fallacies, which I have collected from various sources, are not usually mentioned in books on astronomy, and may prove of interest to the general reader.

It is mentioned in the "Anglo-Saxon Chronicle" that a total eclipse of the sun took place in the year after King Alfred's great battle with the Danes. Now, calculation shows that this eclipse occurred on October 29, 878 A. D. King Alfred's victory over the Danes must therefore have taken place in A. D. 877, and his death probably occurred in A. D. 899. This solar eclipse is also mentioned in the "Annals of Ulster."

It is stated by many historians that an eclipse of the sun took place on the morning of the battle of Crecy, August 26, 1346. But calculation shows that there was no eclipse of the sun visible in England in that year. At the time of the battle the moon had just entered on her first quarter, and she was partially eclipsed six days afterward, on the 1st of September. The mistake seems to have arisen from a mistranslation of the old French word *esclistre*, which means lightning. This was mistaken for *eclipse*. The account seems to indicate that there was a very heavy thunderstorm on the morning of the famous battle.

A dark shade was seen on the waning moon by Messrs. Hirst and J. C. Russell on October 21, 1878, "as dark as the shadow during an eclipse of the moon."† If this observation is correct it is certainly most difficult to explain. Another curious observation is recorded by Mr. E. Stone Wiggins, who says that a partial eclipse of the sun by a dark body was observed in the State of Michigan (U. S. A.) on May 16, 1884, at 7 P. M. The "moon at that moment was 12 deg. south of the equator, and the sun as many degrees north of it." The existence of a dark satellite of the earth is suggested, but this seems highly improbable.

Investigations on ancient eclipses of the moon show that the eclipse mentioned by Josephus as having occurred before the death of Herod is probably that which took place on September 15, B. C. 5. This occurred about 9:45 P. M., and probably about six months before the death of Herod (St. Matthew II., 15).

Kepler states in his *Somnium* that he saw the moon in thin crescent phase on the morning and evening of the *same* day (that is, before and after conjunction with the sun). Kepler could see fourteen stars in the Pleiades with the naked eye, so his eyesight must have been exceptionally keen.

The "moon maiden" is a term applied to a fancied resemblance of a portion of the Sinus Iridum to a female head. It forms the "promontory" known as Cape Heraclides, and may be looked for when the moon's "age" is about 11 days. Mr. C. J. Caswell, who observed it on September 29, 1895, describes it as resembling "a beautiful silver statuette of a graceful female figure with flowing hair."

It has been stated that the moon as seen with the highest powers of the great Yerkes telescope appears "just as it would be seen with the naked eye if it were suspended sixty miles over our heads." But this statement is quite inaccurate. The moon as seen with the naked eye, or in a telescope, shows us nearly a whole hemisphere of its surface. But were the eye placed only 60 miles from its surface we should see only a small portion of its visible hemisphere. In fact, it is a curious paradox that the nearer the eye is to a sphere the less we see of its surface! The truth of this will be evident from the fact that on a level plane an eye placed at a height of, say, 5 feet sees a very small portion of the earth's surface indeed, and the higher we ascend the more of the surface we see. I find that at a distance of 60 miles from the moon's surface we should only see a small fraction of its visible hemisphere (about 1/90). The lunar features would also appear under a different aspect. The view would be more of a landscape than that seen in any telescope. This view of the matter is not new. It has been previously pointed out, especially by M. Flammarion and Mr. Whitmell, but its truth is not, I think, generally recognized. Prof. Newcomb doubts whether with any telescope the moon has ever been seen so well as it would be if brought within 500 miles of the earth.

From careful observations of the Zodiacal Light, Mr. Gavin J. Burns finds that its luminosity is only "some 40 to 50 per cent brighter than the background of the sky. Prof. Newcomb has made a precisely similar remark about the luminosity of the Milky Way, viz., that it is surprisingly small." This agrees with my own observations during many years. It is only on the finest and clearest nights that the Milky Way forms a conspicuous object in the night sky. And this only in the country. The lights of a city almost obliterate it. Mr. Burns finds that the Zodiacal Light appears "to be of a yellowish tint; or if we call it white, then the Milky Way is comparatively of a bluish tint." During my residence in the Punjab, the Zodiacal Light seemed to me constantly visible in the evening sky in the spring months. In the west of Ireland I have seen it nearly as bright as the brighter portions of the Milky Way (February 20, 1890). The "meteoric theory" of the light seems to be the one now generally accepted by astronomers, and in this opinion I fully concur.

From observations of the "Gegenschein," or Zodiacal Counter Glow, Prof. E. E. Barnard finds that it is not so faint as is generally supposed. "It is best seen by averted vision, the face being turned 60 deg. or 70 deg. to the right or left, and the eyes alone turned toward it. It is invisible in June and December, while in September it is round, with a diameter of 20 deg., and very distinct." No satisfactory theory has been advanced to account for this curious phenomenon. Prof. Arthur Seale, of Harvard, attributes it to a number of asteroids too small to be seen individually. In "opposition" these would be fully illuminated and nearest to the earth. Its distance from the earth probably exceeds that of the moon. Dr. Johnstone Stoney thinks that the Gegenschein may possibly be due to a "tail" of hydrogen and helium molecules repelled from the earth by solar action. This "tail" would be visible to us by reflected sunlight. There seems to be "a slight lagging of the Gegenschein behind the anti-solar position," and this would agree with Stoney's theory.

The rotation period of the planet Venus seems to be still uncertain. A slow rotation of about 225 days is favored by Perrotin, Schiaparelli, and Terby, while Neisten, Stuyvaert, Trouvelot, and Leo Brenner support De Vico's old period of about 24 hours.

Projections on the limb of the planet Mars have frequently been observed in America. These are known not to be mountains, as they do not re-appear under similar conditions. They are supposed to be clouds, and one seen in December, 1900, has been explained as a cloud lying at a height of some 13 miles above the surface of the planet and drifting at the rate of about 27 miles an hour. Recent spectroscopic observations at

* Knowledge and Scientific News.

† The Observatory, vol. ii, p. 375.

Mr. Lowell's observatory have proved the existence of water vapor in the atmosphere of Mars. If there are any mountains on Mars they have not yet been discovered. The existence of the so-called "canals" is supposed to be confirmed by Lowell's photographs of the planet; but what these "canals" really represent, that is the question. They have certainly an artificial look about them, and they form one of the most curious problems in the heavens. The late Mr. Proctor thought that Mars is "far the reddest star in the heavens; Aldebaran and Antares are pale beside him."* But this does not agree with my experience. Antares is, to my eye, quite as red as Mars, and the color of Aldebaran is quite comparable with that of the "ruddy planet." In the telescope, the color of Mars is, I believe, more yellow than red, but I have not seen the planet very often in a telescope. Sir John Herschel suggested that the reddish color of Mars may possibly be due to red rocks, like those of the old red sandstone, and the red soil often associated with such rocks, as I have myself noticed near Torquay and other places in Devonshire.

From observations of Uranus made in 1896, Mr. Leo Brenner concluded that the planet rotates on its axis in about 8½ hours (probably 8h. 27m.).

The existence of a second satellite of Neptune is suspected by Prof. Schaeberle, who thinks he saw it with the 36-inch telescope of the Lick Observatory "on an exceptionally fine night in 1895."† But this supposed discovery has not yet been confirmed.

It has often been stated that the old Indian emperor Jehangir "had a sword made from a piece of meteoric iron which fell in the Punjab in the year 1620." According to Sir M. E. Grant Duff, President Diaz, of Mexico, had a sword made from an aerolite.‡

Many attempts have been made by "paradoxers" to show that the earth is a flat plane and not a sphere. But M. Ricco has found by actual experiment that the reflected image of the setting sun, seen from a smooth sea, is an elongated ellipse. This proves mathematically beyond all doubt that the surface of the sea is spherical; for the reflection from a plane surface would be *circular*. The theory of a "flat earth" is, therefore, proved to be quite untenable, and all the arguments (?) of the "earth flatteners" have now been "blown into space."

With reference to the apparent enlargement of celestial bodies near the horizon, M. Paul Stroobant finds that if G is the size of an object at a certain altitude H, then the formula $G = 100 - 19 \sin H$ represents very well the relation between G and H, if we take 100 as the size on the horizon.§ For an object in the zenith this would give $G = 81$.

Mr. Denning thinks that on the return of Halley's comet in 1910, there may possibly be a shower of meteors on about May 4 of that year, "when the earth reaches that part of its orbit corresponding with the descending node of the comet," the earth being then distant about 5½ millions of miles from the comet's orbit.‖

In the Sanskrit epic poem, the "Ramayana," it is stated that at the birth of Rama, the moon was in Cancer, the sun in Aries, Mercury in Taurus, Venus in Pisces, Mars in Capricornus, Jupiter in Cancer, and Saturn in Libra. Mr. Walter R. Old has computed that the corresponding date is February 10, 1761 B. C.¶

The late Mr. Proctor and Prof. Young believed "that the contraction theory of the sun's heat is the true and only available theory." The theory is, of course, a sound one, but it may now be supplemented by supposing the sun to contain a certain small amount of radium. This would bring physics and geology into harmony. Proctor thought that the "sun's real globe is very much smaller than the globe we see. In other words, the process of contraction has gone on further than, judging from the sun's apparent size, we should suppose it to have done, and, therefore, represents more sun work" done in past ages. The truth of this idea seems very probable.

With reference to the nebular hypothesis, Dr. A. R. Wallace argues that "if there exists a sun in the state of expansion in which our sun was when it extended to the orbit of Neptune it would, even with a parallax of 1/60 of a second, show a disk of half a second, which could be seen with the Lick telescope." My reply to this is, that with such an expansion there would probably be very little intrinsic luminosity, and if luminous enough to be visible, the spectrum would be that of a gaseous nebula, and no known *star* gives such a spectrum. But some planetary nebula look like small stars, and with a high power would probably show a disk. On these considerations, Dr. Wallace's objection does not seem to be valid.

It is a popular idea that stars may be seen in the daytime from the bottom of a deep pit or high chimney. But this is not the case, and has been often disproved. Stars may, however, be seen in the daytime with even small telescopes. It is said that a telescope of one-inch aperture will show stars of the second magnitude, like those in the "belt" of Orion, or the brighter stars of the "Plough"; of two inches, stars of the third magnitude; and of four inches, those of the fourth magnitude. But I cannot confirm this from personal observation. It may be so, but I have not tried the experiment.

* Knowledge, May 2, 1886.
† Journal B. A. A., June, 1895.
‡ Journal B. A. A., July, 1908.
§ The Observatory, No. 104, 1885.
‖ Journal B. A. A., No. 4, vol. xii.
¶ Nature, November 2, 1893.

The photographic method of charting the stars, although a great improvement on the old system, seems to have its disadvantages. One of these is that the star images are liable to disappear from the plates in the course of time. The reduction of stellar photograph plates should therefore be carried out as soon as possible after they are taken. Dr. Roberts found that on a plate originally containing 364 stars, no less than 130 had completely disappeared in 9¼ years.*

It has been assumed by some writers on astronomy that the faint stars visible on photographs of the Pleiades are at practically the same distance from the earth as the brighter stars of the cluster, and that consequently there must be an enormous difference in actual size between the brighter and fainter stars. But there is really no warrant for any such assumption. Photographs of the vicinity show that the sky all round the Pleiades is equally rich in faint stars. It seems, therefore, more reasonable to suppose that most of the faint stars visible in the Pleiades are really far behind the cluster in space. For if all the faint stars visible on photographs belonged to the cluster, then if we imagine the cluster removed, a "hole" would be left in the sky, which is, of course, utterly improbable. An examination of the proper motions tends to confirm this view of the matter, and indicates that the Pleiades cluster is a comparatively small one and projected on a background of fainter stars.

It has long been suspected that the famous star 61 Cygni, which is a double star, is a binary system, that is, that the two stars composing it revolve round their common center of gravity, and move through space together. But measures of parallax made by Hermann S. Davis and Wilsing seem to show a difference of parallax between the two components of about 0.08 of a second of arc. This difference of parallax implies a distance of about two and one-quarter "light-years" between the two stars, and "if this is correct, the stars are too remote to form a binary system. The proper motions of 5.21 sec. and 5.15 sec. seem to show that they are moving in nearly parallel directions, but are probably slowly separating." Mr. Lewis, however, thinks that a physical connection probably exists.†

From an examination of the heat radiated by some bright stars made by Dr. E. F. Nicholls in America, with a very sensitive radiometer of his own construction, he found that "we do not receive from Arcturus more heat than we should from a candle at a distance of five or six miles."

From a comparison of Trouvelot's drawing of the small elongated nebula near the great nebula in Andromeda with recent photographs, Mr. Easton infers that this small nebula has probably rotated through an angle of about 15 deg. in 25 years. An examination I have made of photographs taken in different years seems to me to confirm this suspicion, which, if true, is evidently a most interesting phenomenon.

Keeler, Vogel, and Eberhard found that the great Orion nebula is apparently receding from the earth at the rate of about 11 miles a second. As this is about the sun's computed velocity through space in the opposite direction, the nebula is probably at rest. Keeler thought "that a nebula of such vast extent and tenuity is more likely to be at rest relatively to the stars of our system than small compact nebular masses or individual stars."

Ptolemy, in his description of the Milky Way, given in the "Almagest," says nothing whatever of the bright region in Scutum. This is probably due to an omission of the copyists, as it seems impossible to suppose that Ptolemy did not see this remarkable spot.

Easton calls the Milky Way "the most strange and most amazing of optical errors." But I presume he does not suppose the Galaxy to be merely an optical illusion, for the telescope shows that its objective existence is beyond a doubt.

About the middle of September, 1878, Mr. Greely, of Boston (U.S.A.), reported to Mr. E. F. Sawyer (the eminent observer of variable stars), that about the middle of August of that year he had seen the famous variable star, Mira Ceti, of about the second magnitude, although the star did not attain its usual maximum until early in October, 1878. Mr. Greely stated that several nights after he first saw Mira it had faded to fourth or fifth magnitude. If there was no mistake in this observation (and Sawyer could find none) it was quite a unique phenomenon, as nothing of the sort has been observed before or since in the history of this famous star. It looks as if Mr. Greely had observed a new or "temporary" star near the place of Mira Ceti, but as the spot is far from the Milky Way, which is the usual seat of such phenomena, this hypothesis seems improbable.

* Journal B. A. A., October, 1895
† Journal B. A. A., February, 1908.

Dante speaks of the four bright stars in the well-known "Southern Cross" as emblematical of the four cardinal virtues, Justice, Temperance, Fortitude, and Prudence; and he seems to refer to the stars Canopus, Achernar, and Fomalhaut, under the symbols of Faith, Hope, and Charity. The so-called "False Cross" is said to be formed by the stars, κ, ε, δ and ι, of the constellation Argo Navis. But it seems to me that a better (although larger) cross is formed by the stars α Centauri, and α, β, and γ, of Triangulum Australis.

Mr. Monck has pointed out that the names of the brightest stars in the northern hemisphere seem to be arranged alphabetically, in order of color, beginning with red, and ending with blue. Thus we have Aldebaran, Arcturus, Betelgeuse, Capella, Procyon, Regulus, Rigel, Sirius, Spica, and Vega. But as the origin of the names is different this must be merely a curious coincidence.* And, to my eye at least, Betelgeuse is redder than Arcturus.

Some interesting observations made recently by Prof. W. H. Pickering, in Jamaica, made the value of sunlight 540,000 times moonlight. This makes the sun's stellar magnitude to be —26.83, and that of full moonlight —12.5. Prof. Pickering finds that the light of the full moon is equal to 100,000 stars of zero magnitude. He finds that the moon's "albedo" is about 0.0909; or, in other words, that the moon reflects about one-tenth of the light which falls on it from the sun. He also finds that the light of the full moon is about 12 times the light of the half moon; a remarkable and rather a startling result.†

CONSTITUTION OF THE PROTEIN MOLECULE.

The present-day conception of the protein molecule is that it is a complex of different amino acids variously joined together. By energetic hydrolysis of the protein the latter is naturally broken apart into simple fragments represented by the monoamino and diamino acids. When the hydrolysis is carefully conducted as by a weak solution of trypsin, various proteoses result as the primary products, i. e., high molecular polypeptides, which by further action of the enzymes may be successively broken down into simpler polypeptides, such as tetra-, tri-, and dipeptides. Fischer and Abderhalden a few years ago obtained a polypeptide in the pancreatic proteolysis of several proteins which was characterized by being composed solely of glycocoll, proline, and phenylalanine. More recently Osborne and Clapp obtained in the hydrolysis of gliadin what appeared to be a crystalline dipeptide composed of proline and phenylalanine. Further, Fischer and Abderhalden have just described several dipeptides obtained in the partial hydrolysis of proteins; notably, glycocoll and l-tyrosine from silk, glycocoll and l-leucine from elastin and l-leucyl-d-glutaminic acid from gliadin; all characteristic dipeptides. In these results we see suggested the possibility of a primary cleavage of proteins into dissimilar polypeptides and dipeptides with distinct chemical make-up. If such reactions as these do occur, under the influence, for example, of pepsin or trypsin proteolysis, or even through the agency of the duodenal enzyme erepsin, then it is certainly reasonable to consider whether the individual proteoses or polypeptides formed during gastric and pancreatic digestion may not be endowed with different physiological properties. It raises the question whether in the digestion of protein in the gastro-intestinal tract by the enzymes naturally present there a kind of selective cleavage may not occur, in which the various amino acids contained in the protein are split off in special combinations representative of particular lines of attraction or union. Further, a tendency toward the formation of di- and polypeptides having a definite composition, assuming it to exist, may furnish a clue to the way in which the synthesis of protein may be accomplished. Obviously, however, there remains to be discovered first the nature of the 29 to 46 per cent of the protein not yet represented by known decomposition products.

"Brushing-on" Color.—According to Mautner's French patent, the following mixture should be applied to the articles and allowed to dry in: 4 parts egg yolk, 4 parts caseine, 8 parts spirit of sal-ammoniac, 2 parts tartaric acid, 2 parts of alum, 80 parts of distilled water, 1 part of raw albumin, 0.1 part nitrate of soda. To this fluid add the following coloring substances: red, 1 part true red; blue, 1 part Lyons blue and 0.5 part nigrosine; brown, 1 part true brown, 0.5 part nigrosine; green, 0.5 part Lyons blue, 1 part naphthol yellow, 1/3 part nigrosine; yellow, 1 part naphthol yellow. Black brushing-on color: 1.25 parts quillaya bark, 0.5 part bichromate of potash, 3 parts extract of logwood, 0.25 part sulphate of copper, and 60 parts of water.

* The Observatory, April, 1887.
† Annals of Harvard College, vol. xli, part i, 1908.

ENGINEERING NOTES.

During the year ending June 30, 1908, 1,506 vessels, with an aggregate tonnage of 588,627 gross tons, were built in the United States. This is, so far, the largest annual output of the shipbuilding yards in this country. The steel vessels built numbered 142, representing 417,167 gross tons, of which 75 were built for the Great Lakes, with an aggregate tonnage of 304,379 tons. The largest steamer on the lakes built during the year was very nearly 8,000 tons.

A gasoline motor car has been placed in service on a branch of the Waterloo, Cedar Falls & Northern Railway, an interurban electric line. One of the branches of this road has hitherto been operated by steam locomotives, and the motor car is to supplant three passenger trains thus operated in each direction daily. The car has accommodations for twenty passengers and is driven by a 60-horse-power gasoline motor. Radiators are provided under the seats through which water from the jacket-cooling system of the engine is circulated. During the warm weather, when heating is unnecessary, the cooling water is sent through a large radiator under the engine hood. The motor has six cylinders 4½ inches in diameter and 5-inch stroke, and two independent ignition systems, a high-tension magneto and a storage battery. Friction wheels are used for transmitting the power. —Engineering Record.

The Commission of National Defense has just passed the following resolutions with regard to laying down the second track of the Siberian Railway. The second set of rails is to be laid down at once and to be ready for use from Omsk to Irkutsk by January 14 (New Style), 1911. The passage of the trains across Lake Baïkal by means of the huge steam ferry ice-breakers is to be replaced by doubling the railway running round the southern end of the lake, and a project for that work will be laid before the Duma. The Ministry of Ways of Communication is requested to increase the rolling stock of the Siberian Railway and to provide larger trucks of greater carrying capacity. The estimated cost of laying down a second line of rails across Siberia is $19,125,000. But the cost of doubling the track of the Baïkal Ring Railway will be enormous, and the Duma will probably not entertain that project for the present.

The two largest fireboats in the world successfully tested by the New York Fire Department, the "James Duane" and the "Thomas Willett," are the first boats of their type to use steam turbine direct-driven centrifugal pumps. They have a deck length of 131 feet, beam 27 feet, and depth of 14 feet. On a high steel water tower aft, on the two deck turrets, and above the pilot house, 3-inch nozzles are mounted, from which a total of 12,000 gallons of water per minute can be thrown while the boat is moving at full speed. When only one of these four nozzles is left open and the pumps are connected in series, a pressure of 315 pounds at the pumps and of 230 pounds at the nozzle throws a stream of water amounting to 4,550 gallons per minute to a height of 300 feet and a distance of 400 feet. Two Curtis turbine engines are direct-connected to two 12-inch centrifugal Worthington pumps. The former are built to operate at a boiler pressure of 200 pounds and a vacuum of 26 inches at a speed of 1,800 revolutions per minute. They are rated at 660 horse-power, but their overload capacity makes a continuous delivery of 1,000 horse-power possible.

The London Times contains the following in relation to the substitution of steam for other agencies in the propulsion of omnibuses: "It is stated that the London General Omnibus Company has in contemplation the conversion of a considerable portion of its fleet of petrol motor-omnibuses to the Clarkson system of steam traction, a step dictated by the satisfactory working of the Chelmsford omnibuses which the premier London company has already in service. In these chassis the newly designed generator is of the water-tube type. The boiler consists of a central steel shell forged out of a solid ingot in a 1,000-ton press, this shell being machined inside and out and fitted on its outside with generator tubes in the form of a horseshoe, the top of the shell being inclosed in a removable cover. The whole arrangement of shell and tubes is placed within a casing. The control of the paraffin burner is achieved automatically, as is also the case with the feed water, the driver being left free for the management of the car in traffic. The first conversion of such a chassis to the steam system has now been carried out, and a correspondent, who has had an opportunity of taking part in a trial run, can testify to the smooth and satisfactory running of the vehicle. A considerable reduction in weight of the engine has been obtained, and a feature, from the point of view of public service, is the comparative silence in working which has been obtained. It is claimed that under traffic conditions in London the steam omnibus of this type will work at a cost of 8s. 5d. ($2.05) per mile, an appreciable economy in fuel consumption having been achieved on tests extending over many hundreds of miles."

ELECTRICAL NOTES.

Plans have been completed by the United Wireless Telegraph Company to erect eleven new wireless stations on the Pacific coast. The largest, a 5-kilowatt station, will be at Ketchkan, Alaska. Seven will be erected on the trans-Pacific steamships, and three will be land stations. All except the 5-kilowatt station will be 1-kilowatt or 2-kilowatt installations. At present trans-continental communication is possible only when the conditions are most favorable.

The coal economy of locomotives, while it has been considerably improved by the introduction of the compound locomotive, is necessarily limited, and must always be far below that possible with power houses equipped with large boilers and large steam turbines. Power houses are able to use an inferior quality of coal at the mine which is not suitable for any other business. Railways require the best grade of coal. If the railways could obtain their fuel at a price, we will say, about one-third of what they are now paying per ton mile, the saving would be equal to the money which is paid out in dividends. Looked at from these points of view, the prospect for the permanency of the steam locomotive is not bright, and the passing of the steam locomotive may be nearer than many believe.

Heavy steel mill work requires an electric drive capable of withstanding intermittent excessive loads and, in order to reduce the cost of repairs to a minimum, requires a very flexible coupling between the prime mover and the rolls. Electricity offers the most flexible connection known and is the system best suited where excessive variations in power are required. These advantages are so well understood and the system has been so thoroughly tried that there is no hesitation in using electric drive for all the auxiliary apparatus and for even the most severe and exacting conditions met in large continuous or reversing roll work. The waste gases from blast furnaces offer a comparatively cheap source of power when used in connection with an electrical installation, and are utilized for this purpose where the cost of fuel is comparatively high; and even in the United States, where coal is very cheap, the use of blast furnace gases for power purposes has been found advantageous. When power for a mill is bought from an outside company which also furnishes power for purposes requiring good voltage regulation, large fluctuating loads might be objectionable; the excessive intermittent loads common in mill work may be large compared with the capacity of the power station and seriously affect the voltage regulation, especially if motors be used for driving the main rolls. The maximum power required, although it may last for a short time only, determines the maximum size of the station and the cost of power; for this reason power is often sold on the basis of the maximum instead of the average or total power consumed. It is, therefore, desirable to reduce the maximum demands or peak loads as much as possible in order to secure improved regulation and to reduce the cost.

There is one phase in regard to the introduction of electrically-driven tools into the small or average shop which, if overlooked, may be regretted. While electric motors have become extremely reliable, they are, in common with all classes of machinery, prone to some ills of derangement; and as their diseases are entirely different from those with which the average mechanic is at all familiar, he is usually left in a very hopeless position when the motor goes wrong. For this reason some of the large tool builders hesitate to recommend electrically-driven tools for any shop which does not employ a skilled electrician at all times, so that any ordinary derangement can be taken care of at once. It does not take many hours' delay caused by a motor being disabled and the machine out of commission, to offset a considerable saving in output, and it also induces a feeling of insecurity which is far from pleasing to any shop management. One of the large machine-tool shops in question uses electrically-driven tools exclusively, and believes it is the only way to drive machines when you have electrical equipment enough to warrant the employment of the electrician. Among other appliances in this shop are two large planers controlled entirely by electrical apparatus in such a way that there are gradual changes of speed of the table during reversal and going to high speed on the return stroke, all of which involves somewhat complicated electrical apparatus. In this shop no trouble whatever has been experienced from this source, because at the slightest indication of trouble the electrician was summoned and everything kept in first-class order at all times. But in the average shop such a machine would very likely be out of commission half of the time, and the entire apparatus would probably be condemned as a complete failure. Electrical driving of machine tools has come to stay until something better is devised, but it is advisable to consider all phases of the question before going into it in a small way, as there are chances of being disappointed in some of the ways mentioned.—American Machinist.

TRADE NOTES AND FORMULÆ.

Blue Coloring for Iron.—A blue color on polished iron, resembling the blue annealed color, is obtained by immersing the bright iron articles in a mixture of a solution of 140 parts of hyposulphite of soda in 1,000 parts of water and a solution of 35 parts of acetate of lead in 1,000 parts of water and bringing the mixture gradually to the boiling point.

Picture Varnish.—I. 360 parts of finest mastic, 50 parts of Venice turpentine, 15 parts of camphor, 230 parts of rectified French oil of turpentine, and 1,000 parts of 96 per cent alcohol. The preparation is effected in the water bath. II. 240 parts of mastic, 50 parts of Venice turpentine, 1,000 parts oil of turpentine, are mixed and dissolved.

Paint for Damp Cellars.—93 parts of pulverized brick and 7 parts of litharge are stirred together with a sufficient quantity of linseed oil. Both substances should be separately pulverized, then mixed together and mixed with enough linseed oil to make a sort of paste. The mass, applied to the walls, hardens in from three to four days and does not permit the passage of any more moisture.

Bay rum used as a wash after shaving is prepared, according to a German recipe, as follows: 15 parts of bay oil, 3.7 parts acetic ether, 1,700 parts of alcohol, 59 parts powdered talcum, 2,840 parts of water, 1.94 parts saffron. The bay oil, ether, alcohol, and talcum are mixed, well shaken up together, then the water and saffron added, then shake it up again, and after allowing it to stand for twenty-four hours, the whole is to be filtered.

Lighting fat (consistent) which remains fluid during the burning period and afterward solidifies, is obtained as follows: 2 parts of mineral oil of 150 deg. and 2 parts of mineral oil of 300 deg. are heated in a kettle to 150 deg. F. (66 deg. C.) and a sufficient quantity of anchusa (alkanet) added to color the mixture red. Also melt 1 part of paraffine wax (mineral wax) and press into it 2 parts of white sperm oil or spermaceti. Finally, pour both solutions together and mix very thoroughly until they cool. We obtain in this manner a consistent oil, that melts at 273 deg. F. and can be burned in a lamp with a wick.

Water-Proof Paint (by Haase of Weida).—Boil 750 parts of linseed oil with 33 parts each of litharge and rosin, 5 parts each of red lead and amber, add gradually 23 parts of white vitriol and a solution of 35 parts each of caustic potash and alum in 1,500 parts of water. For the ground or priming, add to 500 parts of chalk and 100 parts of zinc-white, 300 parts of water in which 5 parts of alum have been dissolved, and mix with this a decoction of 75 parts of glue with 200 parts of water. This paint is mixed with 200 to 250 parts of the above varnish and thinned with petroleum.

Asphalt Mastix.—With finely divided unburned limestone or fine sand, or a mixture of both, a composition of about 80 parts of refined Trinidad asphalt and about 20 parts of heavy petroleum oil or petroleum residue is intimately mixed, by adding 20 to 30 parts of the composition to 80 to 70 parts of the sandstone, heating and freeing it from moisture. The mixture may be molded into blocks of any desired form and size. To use the mass for any purpose for which asphalt mastix is applicable, make it plastic in a kettle, in which a little of the asphalt composition has previously been placed, adding at the same time, 20 to 60 per cent of fine gravel.

Bengal Fire for Theaters, Illuminating, etc.—Dark blue: 1 part sulphur, 1 part burnt alum, 1 part carbonate of copper, 1 part shellac, 4 parts chlorate of potash. Light blue: 1 part sulphur, 2 parts burnt alum, 4 parts chlorate of potash, 1 part shellac. Dark green: 4 parts nitrate of barium, 1 part boracic acid, 1 part sulphur, 3 parts chlorate of potash, 2 parts shellac. Dark red: 6 parts nitrate of strontium, 2 parts chlorate of potash, 1 part sulphur, 1 part shellac. Light red is obtained if in the preceding recipe the nitrate of strontium is reduced one-half. Violet: 1 part burnt alum, 1 part carbonate of potash, 1 part sulphur, 4 parts chlorate of potash, 1 part shellac. White: 32 parts of nitrate of potash, 1 part of wood charcoal, 4 parts sulphur, 4 parts shellac. Yellow: 1 part sulphur, 2 parts dry carbonate of potash, 5 parts chloride of potash, 1 part shellac.

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